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REUTILIZATION OF WASTEWATER RECYCLED THROUGH GROUND WATER

Volume I

PROGRESS REPORT 1965 - 1968

Demonstration Project Grant FWPCA 16060 DDZ

December 1968

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Eastern Municipal Water District

Hemet, California

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REUTILIZATION OF WASTEWATER
RECYCLED THROUGH GROUND WATER

PROGRESS REPORT 1965-1968
DEMONSTRATION PROJECT GRANT FWPCA 16060 DDZ
DECEMBER 1968

VOLUME I

Eastern Municipal Water District
24550 San Jacinto Street
Post Office Box 858
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CHAPTER I

INTRODUCTION

Purpose and Scope of Study

In December 1964 the FWPCA (then the Division of Water Supply and Pollution Control, U. S. Public Health Service) authorized the Eastern Municipal Water District to undertake a study of water quality factors involved in a program being initiated by EMWD at that time for reclaiming waste waters through treatment and recharge of ground water. The original 3-year study was initiated in January 1965 and has been extended to cover the three and one-half year period ending June 1971. The budget for the study, in terms of both the Federal and EMWD contributions, has averaged approximately $65,000 per year and will continue on a slightly reduced budget.

It is the purpose of this report to present the findings and conclusions of the first four years of study, together with recommendations for the remaining two and one-half years of investigations.

In July 1965, EMWD completed construction of a new sewage system and waste treatment facility, of 2.5 mgd capacity, serving the metropolitan area of the Hemet-San Jacinto Valley of Riverside County (see Figure I-1). The new facility, employing the activated sludge process, was designed to dispose of all of the plant effluent by spreading on basins located in the San Jacinto River cone, in order to recharge the ground water storage in the underlying ground water basin, known as the Upper San Jacinto Ground Water Basin.

The safe yield of this basin was thought to be of the magnitude from 20,000 to 30,000 acre feet per year, which is far less than the growing water supply needs of the area. To make up the deficiency, since 1952 the EMWD has been importing fresh water from the Colorado River through the Metropolitan Water District of Southern California, and the amount of this import now is approximately 40,000 acre feet per year. In planning the new waste treatment and disposal facilities for the Hemet-San Jacinto area, EMWD provided for ground water recharging as the method of final disposal in order to help solve the overall water supply problem of the region.

At its initial flow of 1.0 mgd, the new plant produces 1050 acre feet/year available for recharge, which equals about 9 percent of the safe yield, which has now been determined to be only about 11,000 ac. ft./yr. As the plant is expanded to its planned future capacity of 15 mgd by 1980(1), the volume of recharge will approximate 17,000 acre feet/year or about 145% of the safe yield. Moreover, the Upper San Jacinto Ground Water Basin is essentially a closed ground water basin. In this situation, it is expected that water quality changes in the ground water may be significant and may eventually require addition of special treatment processes for removing both specific mineral and gross mineral substances.

The primary purpose of this study has been to evaluate the water quality factors involved in the recharging, in order that the overall operation be conducted in a manner which provides adequate protection of ground water quality while at the same time permitting the EMWD to carry on recharging activities to reclaim wastes to the extent feasible as a means of regional water conservation. The plans of EMWD for the future envision a number of similar reclamation operations at other communities in the District, which includes some 350,000 acres in Riverside County.

Another specific objective of the study is to quantify the benefits, to the salt balance problem in the region, of planned reclamation by recharging as compared with the previous situation wherein the effluents from the previous two water treatment plants (operated by the cities of Hemet and San Jacinto, which were abandoned on completion of the new facility) were simply discharged to the San Jacinto River area. The effluents from the previous plants were used partially as irrigation water by interested farmers. Under the planned reclamation there is a significant reduction in evapotranspiration losses, thus significantly improving ground water quality by lessening the concentration of dissolved salts.

Organization of Study

The administrative set-up for the project is shown on the last page of this volume immediately following the References Cited. This shows that the work force for the project has comprised a Project Director, Project Engineer, Assistant Engineers, chemist, draftsmen, field personnel, and additional supporting personnel of EMWD.

In addition to the Project Staff, the study participants include a Project Control Board and a Project Advisory Committee.

The purpose of the Project Control Board is to plan the study and supervise the activities of the staff from a policy point of view. Members of the Control Board are Doyle F. Boen, Project Director and Chairman; Richard Bueermann, Executive Officer, Santa Ana River Basin Regional Water Quality Control Board; Prof. Albert Bush, University of California at Los Angeles; Dr. Harvey F. Ludwig, President, Engineering-Science, Inc.; Dr. Jack E. McKee, California Institute of Technology; James E. Lenihan, Project Engineer and Secretary. The Control Board met regularly at intervals of three to four months.

The purpose of the Advisory Committee is to bring into the study the guidance and advice of all interested public agencies willing to contribute. The members are Paul Bonderson, Executive Officer, California Water

Quality Control Board, Sacramento, Arthur Reinhardt, California State Department of Public Health, Los Angeles; Maurice Hawkins, Riverside County Health Department; John Bryant, Riverside County Flood Control and Water Conservation District; David Willets, Mitchell L. Gould and presently Robert Chun, California State Dept. of Water Resources, Los Angeles; John Parkhurst, Los Angeles County Sanitation Districts, and Arthur E. Bruington, Los Angeles County Flood Control District.

The Advisory Committee meets annually.

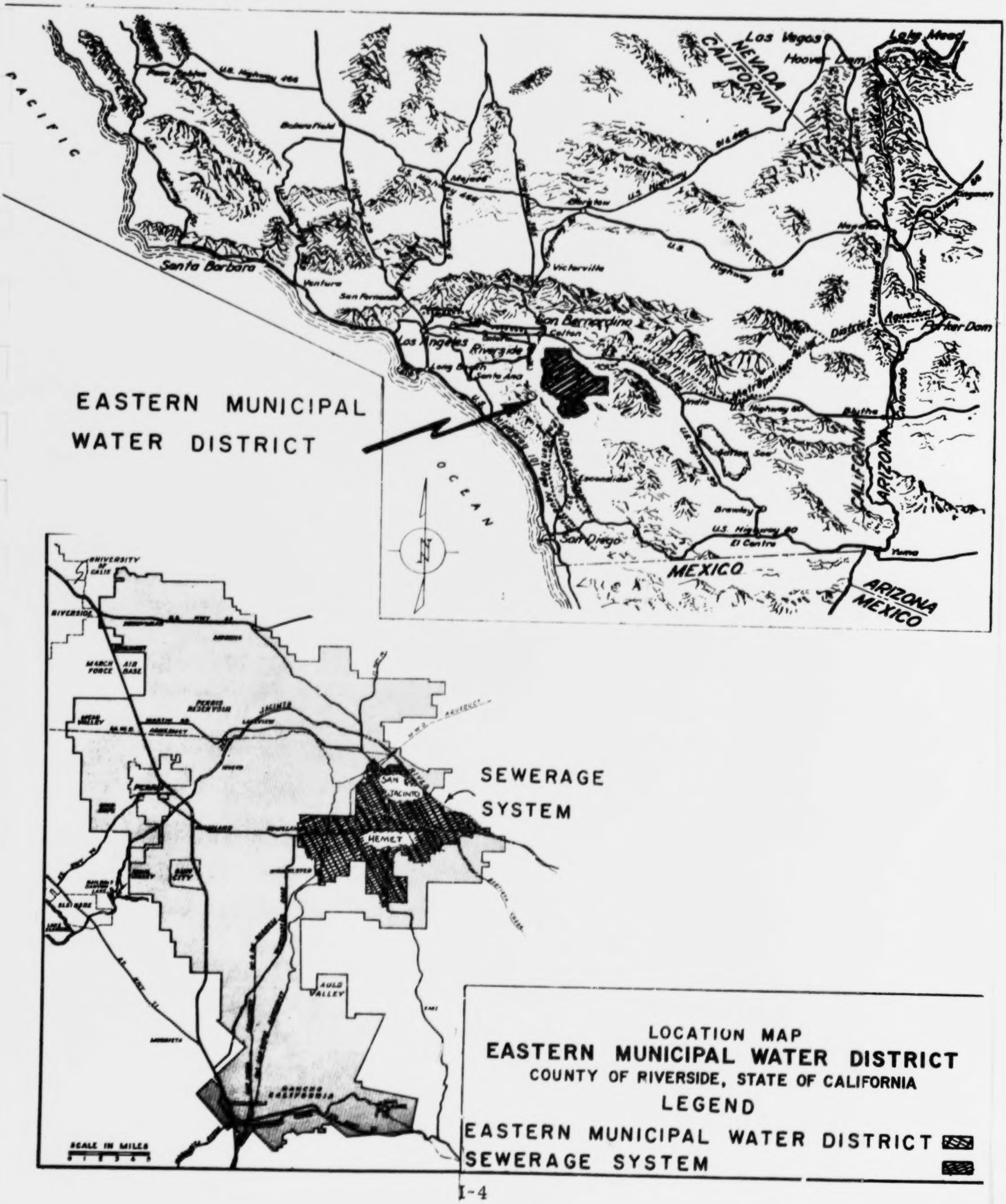
The main work of the project has included essentially the following elements:

1. Evaluation and Development of Pertinent Background Information:
    a. General Description of Ground Water Basin
    b. Geology of Basin
    c. Maximum Safe Yield of Basin
2. Spreading Activities
3. Sampling and Analyses of Infiltrated Water
4. Study of Ground Water:
    a. Hydrology
    b. Sampling and Analyses
5. Evaluation of (1) through (4) to Develop Findings, Conclusions and Recommendations

Acknowledgment

It is not feasible to list each and every institution, agency and individual contributing to this project as they are far too numerous. However, the authors are especially indebted to the following: Dr. Gordon Eaton and the University of California at Riverside, State of California Department of Water Resources, Los Angeles County Flood Control District, Riverside County Flood Control and Water Conservation District, Engineering-Science, Inc. of Arcadia, and to the large group of local farmers and landowners who allowed the EMWD to traverse their land for geological surveys and to use their land for seismic surveys. Also, the District is indebted to the owners of the wells immediately surrounding the replenishment area, as these people have allowed and are continuing to allow unlimited access to their wells.

FIGURE I-1


EASTERN MUNICIPAL WATER DISTRICT
SEWERAGE SYSTEM
PACIFIC
OCEAN
NEVADA
CALIFORNIA
ARIZONA
MEXICO
Los Vegas
Hoover Dam
Lake Mead
Santa Barbara
Ventura
San Fernando
Los Angeles
Riverside
Long Beach
Santa Ana
San Bernardino
Colton
Victorville
Barstow
Mojave
Bakersfield
Paso Robles
Escondido
San Diego
Brawley
El Centro
Yuma
Blythe
Parker Dam
Salton Sea
Metropolitan Water District Aqueduct
Colorado River
U.S. Highway 66
U.S. Highway 60
U.S. Highway 80
U.S. Highway 99
U.S. Highway 466
N
UNIVERSITY OF CALIF.
RIVERSIDE
MARCH AIR FORCE BASE
PERRIS RESERVOIR
M.W.D. AQUEDUCT
SAN JACINTO
HEMET
PERRIS
SUN CITY
ELSINORE
AULD VALLEY
RANCHO CALIFORNIA
SCALE IN MILES
0 1 2 3 4 5

LOCATION MAP
EASTERN MUNICIPAL WATER DISTRICT
COUNTY OF RIVERSIDE, STATE OF CALIFORNIA
LEGEND

EASTERN MUNICIPAL WATER DISTRICT	▨
SEWERAGE SYSTEM	▨

CHAPTER II

UPPER SAN JACINTO GROUND WATER BASIN

The Upper San Jacinto Ground Water Basin is herein defined as that group of sediments that in general are bounded by the Casa Loma Fault on the southwest, the San Jacinto Fault on the northeast, the mouth of Bautista Canyon on the southeast, and Theodore Street in the Moreno area on the northwest. Specifically, it lies within the San Jacinto Hydro Sub-area of the Santa Ana Drainage Province of the Southern District of the State of California, as per the State Department of Water Resources. See Figure II-1.

The Upper San Jacinto Ground Water Basin is located in the western part of Riverside County, California. The major watershed areas of the ground water basin are the mountains on the eastern edge, with the highest peak, Mt. San Jacinto, at elevation 10, 805 feet above sea level, being more than 8, 500 feet above the ground water basin. The San Jacinto River, the major drainage channel for the entire Hydro Unit, carries wet weather runoff from the eastern portion of the Hydro Unit northwesterly through and over the Upper Ground Water Basin and thence westerly into and through Railroad Canyon Reservoir to Lake Elsinore. Historically, Lake Elsinore has overflowed into Temescal Wash and thence into the Santa Ana River near Corona, but this has not occurred since 1916. The entire San Jacinto Valley Hydro Unit is in essence a closed basin with occasional surface outflow, but no apparent subsurface outflow.(2)

General Description

The Upper San Jacinto Ground Water Basin is a long, narrow ground water basin, 20 miles by 3 miles, with the long axis oriented in a northwest-southeast direction. It is a graben or a portion of a graben(3) caused by extensive down faulting along both the San Jacinto and Casa Loma Fault Zones concurrent with sediment deposition over a long period of time.

Surface runoff drains from the northeast, southeast and northwest to just northwest of the middle of the ground water basin and then westerly toward Lakeview.

The overlying surface of the ground water basin is sparsely populated with the City of San Jacinto, population 3, 800, being the only moderate concentration of people. The southeast portion has citrus groves and other agriculture, supported by a good supply of ground water from the Canyon Sub-Basin, which here is considered a part of the ground water basin, even though it is apparently east of the San Jacinto Fault. The ground water becomes less available toward the northwest portion of the ground water basin and this is reflected on the ground surface by finer sediments and dry farming.

The Upper San Jacinto Ground Water Basin is essentially closed with occasional surface outflow, but no subsurface outflow. The ground water basin has several sub-areas which have been previously investigated and labeled and will be briefly described here. See Figure II-2. Knowledge of ground water movement in these sub-areas is necessary for an understanding of the hydraulics of the entire basin.

Hydrogeology

Canyon Sub-Basin - In this area, the San Jacinto Fault and possibly less permeable sediments to the west apparently restrict the movement of ground water in the sediments underlying and adjacent to the river channel. The ground water levels are usually at substantially higher elevations on the upstream or east side than levels on the downstream side. A difference on the order of 225 feet was observed in the spring of 1968. The greatest part of the San Jacinto Valley Hydro Unit runoff runs into this sub-basin as the San Jacinto River and, due to the flat slope and the coarse alluvial material present, it has excellent recharge characteristics with its water table fluctuating as much as 100 feet annually. Due to the water table rising to or near the ground surface consistently, local inhabitants have termed this area the "Cienega". It is here included as part of the Upper San Jacinto Ground Water Basin since it can act as a buffer or reservoir and undoubtedly has a pronounced effect on the recharge of the main basin.

Bautista Outwash Area - The alluvial fan at the mouth of Bautista Canyon bordered by the San Jacinto Fault on the northeast and the Casa Loma Fault or possibly the Park Hill Fault on the southwest, and the area extending to the vicinity of Cedar Avenue has been termed the "Bautista Outwash Area". The existence of the Park Hill Fault is questionable; however, the presence of Park Hill and its proximity to the Casa Loma Fault along with the southeast-northwest aligned old Bautista Wash on the northeast side of Park Hill has led some geologists to speculate that a fault must exist.(2) The ground water hydraulic gradient governs flow into or out of the area.

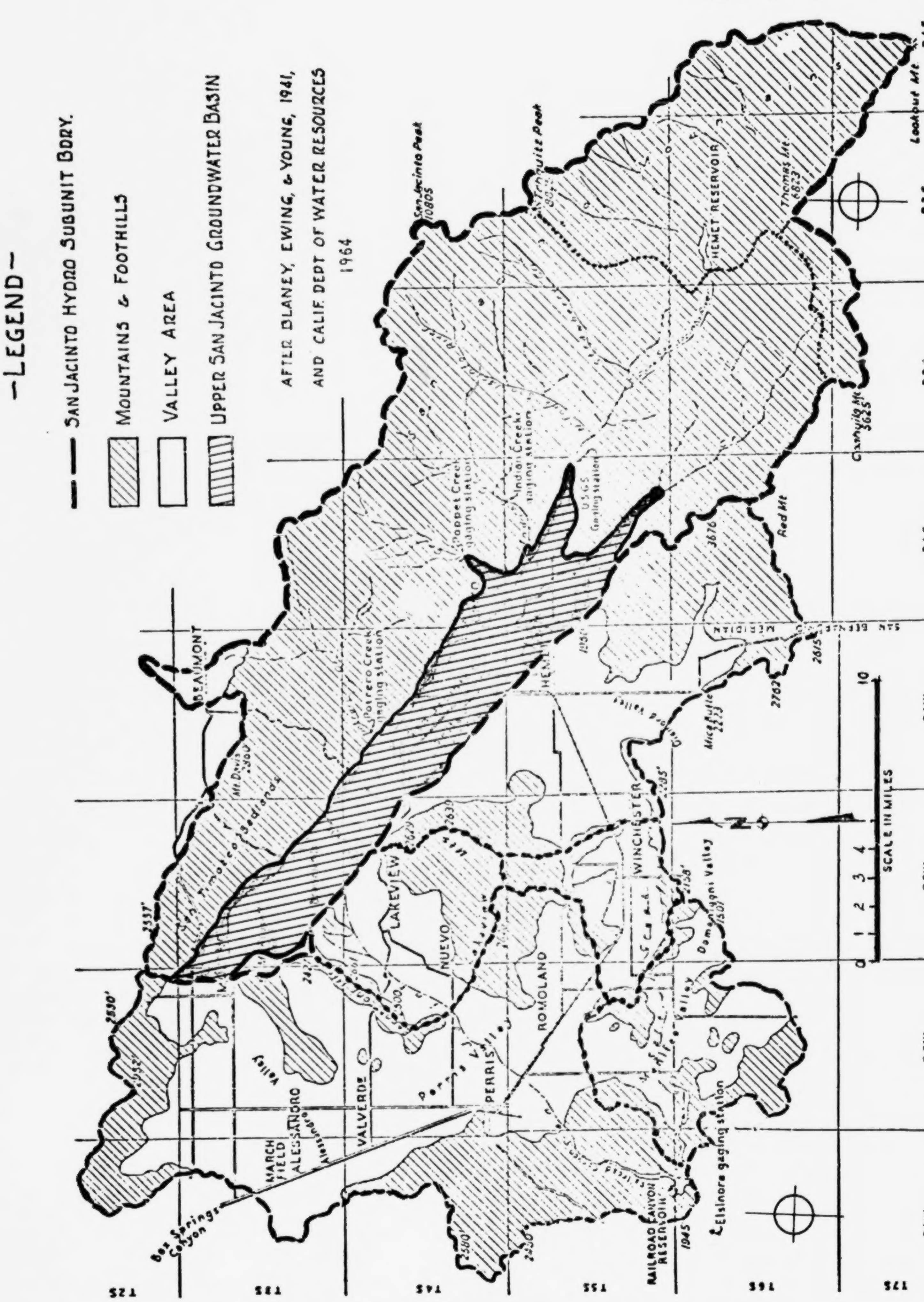
In the past, e.g., 1940, ground water levels on opposite sides of the Casa Loma Fault have shown higher water levels on the northeast side of this fault as compared with those levels on the southwest. In the spring of 1968 the reverse was found to exist, due to the continuing overdraft of the ground water basin. Both situations point to the low permeability of the Casa Loma Fault.

Intake Area - The San Jacinto Fault, the Park Hill Fault, and the southeasterly edge of the Pressure Area enclose a roughly triangular area. This area has been named the "Intake Area". It is probably on the order of 500 feet thick and is underlain by highly impermeable sedimentary deposits to a considerable depth. Water flowing in the San Jacinto River channel through this area readily replenishes ground water storage therein. Water flowing either over the San Jacinto Fault or through the fault near the ground surface from the upstream Canyon Sub-Basin and any underground flow from Bautista Canyon also replenish storage in this area. The water stored underground in the Intake Area historically supplied the confined ground water underlying the Pressure Area so that extractions of ground water in both the Intake and Pressure Areas were supplied from recharge of the Intake Area. For the last year (1968) or more, the ground water gradient has been reversed from a surface dipping northwesterly to a depression or trough with a major portion of the deep ground water surface sloping southeasterly from the Pressure Area toward the Intake Area. See Figures II-3 and II-4.

Pressure Area - Within the area between the Casa Loma and the San Jacinto Faults from the City of San Jacinto northwestward, data from well logs and excavations reveal a substantial multi-layered zone of relatively impervious sediments and pervious water-bearing sediments. Prior to 1950 when ground water levels were near the surface, many artesian wells were encountered in this area, indicating that underlying ground water was under pressure as a result of confinement by the impervious layers. In 1942 one well in particular was observed with an artesian head of 45 feet. The southeasterly, or upstream extremity of this area has been delineated in previous reports and is shown by the dotted line in Figure II-2.

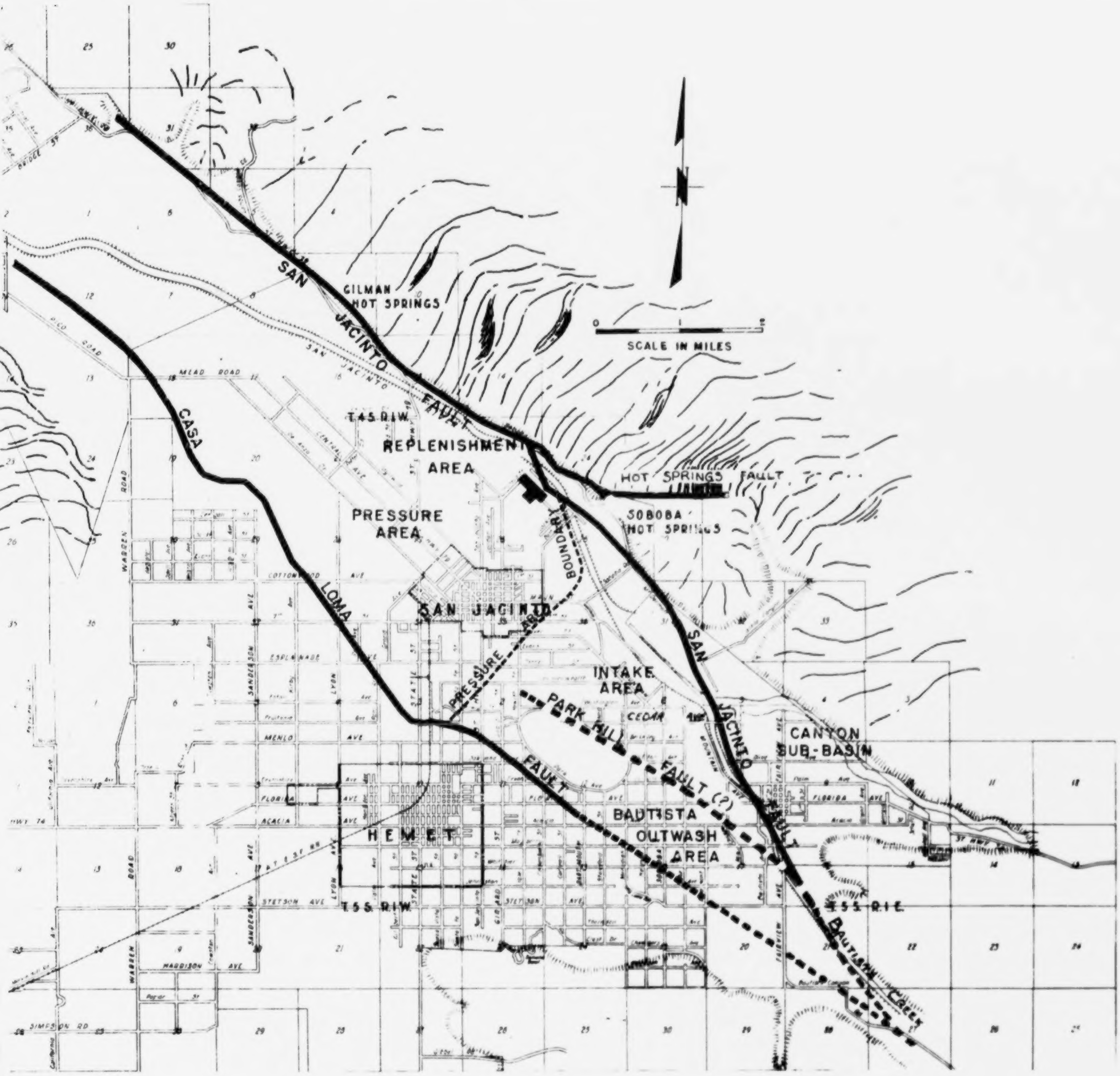
The area to the northwest of this line has been designated the "Pressure Area". Depression of ground water levels in this area and in the Intake Area has reduced or eliminated the artesian effects experienced earlier in the Pressure Area. Heavy pumping in recent years has depressed the ground water table to more than 170 feet below the ground surface. The pressure effects might still be present to some degree as evidenced by the diversity of well water levels observed in the fall of 1968. Several miles to the northwest of the Pressure Area impervious sediments and possibly the Casa Loma Fault apparently form a barrier to the movement of ground water. This bottom land or depression is a result of faulting and land subsidence due to water withdrawal and is the site of an intermittent lake. Water wells drilled in this bottom land have produced appreciable amounts of "marsh" gas resulting in the drilling by others of a few speculative oil wells that were "dusters".

FIGURE II-1


-LEGEND-
SAN JACINTO HYDRO SUBUNIT BDRY.
MOUNTAINS & FOOTHILLS
VALLEY AREA
UPPER SAN JACINTO GROUNDWATER BASIN
AFTER BLANEY, EWING, & YOUNG, 1941, AND CALIF. DEPT OF WATER RESOURCES 1964
BEAUMONT
San Jacinto Peak 10805
HEMET RESERVOIR
Thomas Mt. 6823
Lookout Mt.
Red Mt.
SAN BERNARDINO MERIDIAN
HEMET
WINCHESTER
LAKEVIEW
NUEVO
ROMOLAND
PERRIS
VALVERDE
MARCH FIELD
ALESSANDRO
Box Springs Canyon
RAILROAD CANYON RESERVOIR
Elsinore gaging station
Domenigoni Valley
Potrero Creek gaging station
SCALE IN MILES
0 1 2 3 4 10
R4W R3W R2W R1W R1E R2E R3E R4E
T2S T3S T4S T5S T6S T7S

UPPER SAN JACINTO GROUND WATER BASIN LOCATION

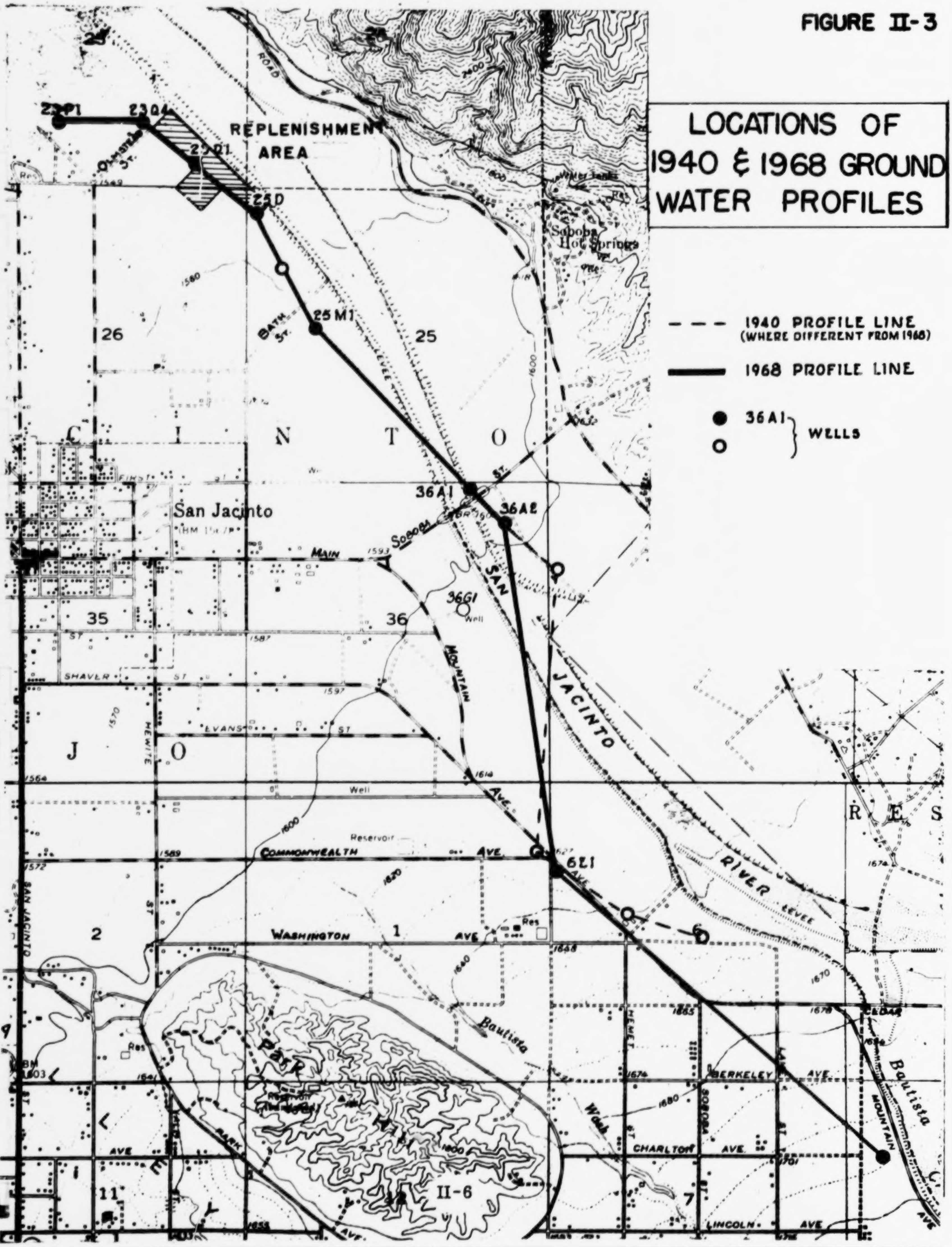
FIGURE II-2


N
SCALE IN MILES
0
1
2
SAN JACINTO FAULT
GILMAN HOT SPRINGS
SAN JACINTO RIVER
PICO ROAD
MEAD ROAD
T4S R1W
REPLENISHMENT AREA
HOT SPRINGS FAULT
PRESSURE AREA
SOBOBA HOT SPRINGS
BOUNDARY
CASA LOMA FAULT
WARREN ROAD
COTTONWOOD AVE
SAN JACINTO
SANDERSON AVE
ESPLANADE
PRESSURE
INTAKE AREA
PARK HILL FAULT (?)
CEDAR
SAN JACINTO FAULT
CANYON SUB-BASIN
MENLO AVE
FLORIDA AVE
ACACIA AVE
HWY 74
HEMET
BAUTISTA OUTWASH AREA
STETSON AVE
T5S R1W
T5S R1E
BAUTISTA CREEK
HARRISON AVE
SIMPSON RD

AFTER PROCTOR, 1968,
FETT 1967, SHARP 1963,
& STATE OF CALIF. BUL. #15
APP. B 1959.

UPPER SAN JACINTO GROUND WATER BASIN SUB-AREAS

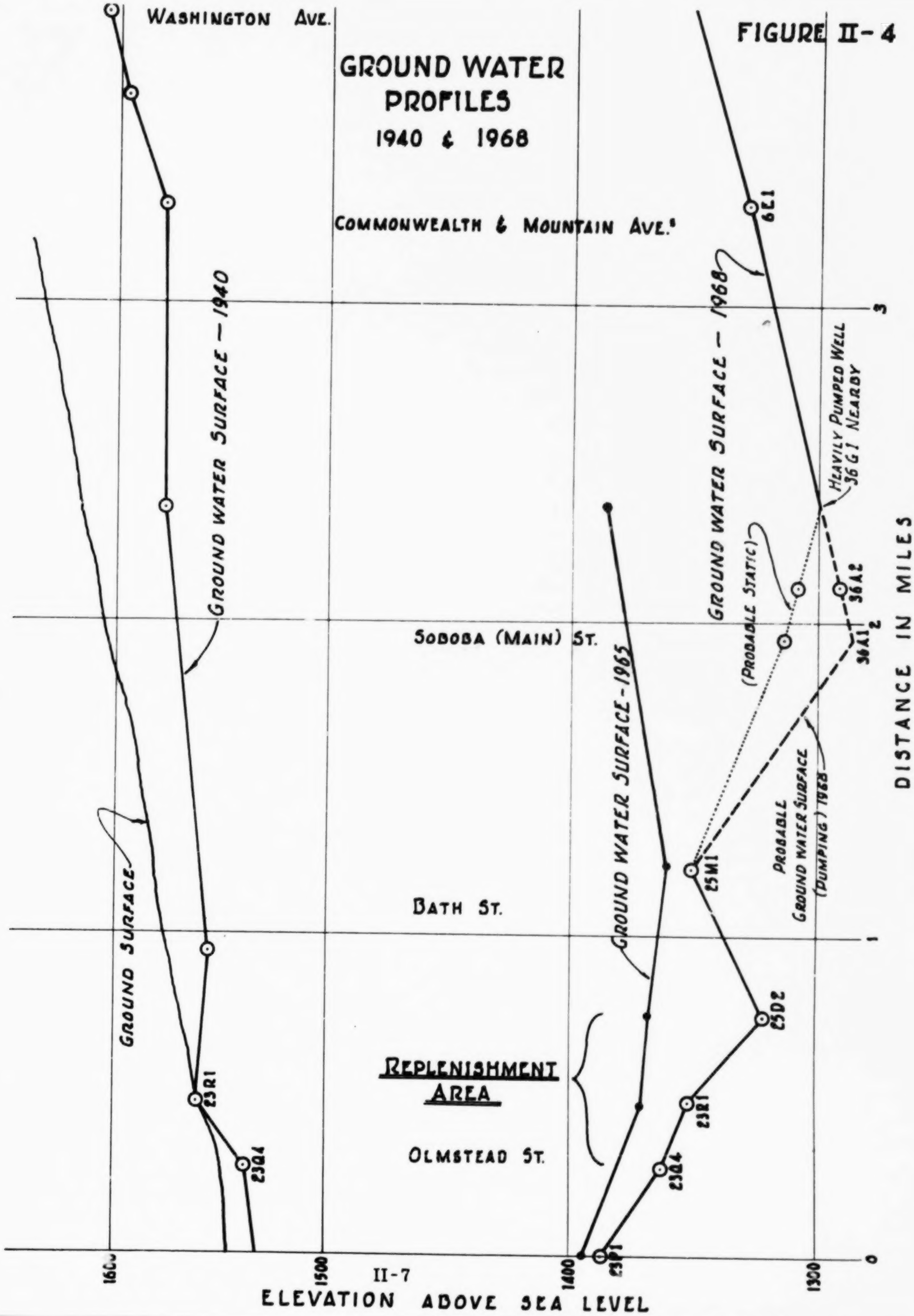
FIGURE II-3


1940 PROFILE LINE (WHERE DIFFERENT FROM 1968)
1968 PROFILE LINE
● 36A1
○
WELLS
REPLENISHMENT AREA
23P1
23Q4
25D1
25D
25M1
36A1
36A2
36G1
6L1
26
25
35
36
2
1
6
7
11
II-6
C I N T O
J O
R E S
San Jacinto
Soboba Hot Springs
SAN JACINTO RIVER
LEVEE
MOUNTAIN AVE.
COMMONWEALTH AVE.
WASHINGTON AVE.
MAIN
FIRST ST.
SHAVER ST.
EVANS ST.
BERKELEY AVE.
CHARLTON AVE.
LINCOLN AVE.
CEDAR
HEWITT ST.
SOBOBA ST.
STATE ST.
BATH ST.
Bautista
Bautista Wash
Park Hill
Reservoir
Well

LOCATIONS OF 1940 & 1968 GROUND WATER PROFILES

FIGURE II-4

GROUND WATER PROFILES
1940 & 1968



CHAPTER III

GEOPHYSICAL INVESTIGATION OF THE UPPER SAN JACINTO GROUND WATER BASIN

During the early stages of this study, while well log data were being obtained, an anomaly in the data became apparent. This anomaly was the fact that wells in the central portion of the ground water basin, that is the Pressure Area and the northern portion of the Intake Area, had not been drilled to bedrock. Upon investigation, it was found that none of the wells drilled between the Casa Loma and San Jacinto Faults, in the San Jacinto Valley had ever reached bedrock. One of these wells was over 2200 feet deep and only one-half mile from bedrock outcrops across the Casa Loma Fault. Near the San Jacinto Fault, this difference was just as surprising; there were outcrops of bedrock one-quarter of a mile from wells over 800 feet deep which had not hit bedrock.

It is desirable that a study such as this have as much knowledge as possible about its ground water basin. The University of California at Riverside, located immediately north of this District, was contacted concerning the availability of a geophysics class to assist project personnel in determining the depth of the ground water basin.

Dr. Gordon Eaton, then Chairman of the Geophysics Department at UCR, together with one of his graduate classes, worked over a year on magnetometer, gravity and seismic surveys needed to determine depth to bedrock in the basin. Drs. Shawn Biehler and Stuart Smith from California Institute of Technology, along with one of their graduate classes, worked long and diligently on the seismic surveys and the reduction of the data. John Fett, a local geologist, donated many days of work along with his equipment, to these surveys. Mr. Fett was later engaged as a consultant to summarize the geology of the Upper San Jacinto Ground Water Basin based on the findings of the above surveys. The portion of Mr. Fett's report not shown below is contained in Appendix 3, Volume II, of this report.

Geology

The geologic relations in the area are largely controlled by faulting with alluvial soil filling against faulted blocks and, to the southwest of the Casa Loma Fault, against remnant high points of metamorphic and igneous rocks. The alluvial soils are themselves cut by faults, some forming escarpments at the surface and others evidenced by anomalous ground water conditions.

The metamorphic rocks are mostly schists and gneisses, while the igneous rocks are mostly Cretaceous tonalites and granodiorites.

The ground water basin is mainly composed of Recent-late Quaternary sediments and were probably deposited by stream flow while the Park and Casa Loma Hills, the hills east of Bautista Creek, the Badlands to the northwest of the basin and much of the Soboba reservation are late Tertiary early Quaternary sediments.

Magnetometer and Gravity Surveys

These surveys were run on five lines crossing the ground water basin orthogonally to its long axis. The horizontal and vertical control for each station was established by EMWD surveyors pursuant to directions received from Dr. Eaton. Figure III-1 depicts these survey lines and it is interesting to note that several of the lines traverse steep terrain. Obviously, this experience taught the students how to hike as well as the techniques of gravity surveying.

Since the work was conducted in part for student instruction and the magnetometer survey data yielded no appreciable information, it was discontinued after two lines were run in the vicinity of Survey Lines A and B, as this was sufficient for instruction purposes. The geology is apparently not susceptible to magnetometer work due to the similarity between the magnetic properties of the sediments and the adjoining crystalline rock.

Most of the gravity data obtained are being reduced in detail by an electronic computer under the direction of Dr. Shawn Biehler.* A portion of the gravity survey, conducted by Mr. John Fett, has been reduced by a desk calculator without total compensation for terrain correction. A Bouguer anomaly map was prepared and can be found in Appendix 3.

When the gravity survey indicated the depth to bedrock was 3,000 feet or greater, the gravity survey method of determining depth became more qualitative than quantitative as sediment bulk densities are not known in detail.

Seismic Survey

To determine the depth of the valley sediments more accurately, a seismic refraction survey was conducted. The personnel involved at any particular time varied from three District employees and Mr. Fett, to five District employees, Mr. Fett, Drs. Shawn Biehler and Stuart Smith with their graduate geophysics class from California Institute of Technology and Dr. Eaton and his graduate geophysics class from UCR.

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*Dr. Biehler is presently at Massachusetts Institute of Technology; formerly he was at California Institute of Technology.

The seismic velocity of granitic bedrock in the area of investigation was first determined by Dr. Eaton and Mr. Fett, using a Texas Instrument EXPLORER system. Measurements were made on the northwest side of the Lakeview Mountains, both across foliation and along foliation. The rock was found to be anisotropic, with a minimum velocity of about 14,500 feet per second across foliation and a maximum velocity of about 17,000 feet per second along foliation. A commercial seismic investigation in the area found seismic velocity of unweathered metamorphic bedrock to be 15,000 to 16,000 feet per second.

Four separate seismic lines were explored and these lines are shown on Figure III-2. The major seismic work was conducted along Line A. The shot point, Shot Point 1, was at the northwest end of the line and was located in the San Jacinto River bed just west of the junction of Massacre Canyon Creek and the river. To facilitate the use of three separate geophone strings during the seismic work on Line A, the shot instant was radioed to recording units by CIT's tone generating blaster. Several seconds before shot time a 400 Hz tone was transmitted and was interrupted at the precise instant of cap detonation. This signal was placed on seismic records by auxiliary galvanometers.

To verify the findings of the above work and to determine the dip of bedrock, Line A was reversed by Mr. Fett and Dr. Eaton with his geophysics students, Shot Point 2 was at the southeast end of Line A, in Bautista Creek, just north of Cedar Avenue.

To reduce the explosive costs, Mr. Fett instructed EMWD personnel in the use of ammonium nitrate-fuel oil explosive. Use of this mixture reduced explosive costs to one-half that of conventional explosives used at Shot Point 1.

Shot holes were dug with a backhoe to 11 feet in depth. In contrast to Shot Point 1, where up to 500 lbs. of explosive were buried in one hole, charges were limited to 120 lbs. per hole at Shot Point 2. Where additional energy was required, several holes were connected by a Primacord detonating fuse. The shot hole loading techniques used at Shot Point 2 induced more energy into generation of seismic waves and also reduced cratering.

The original data from Shot Point 1 and Line A as interpreted by Eaton is as follows:

Sediment layers - V = velocity; fps = feet per second

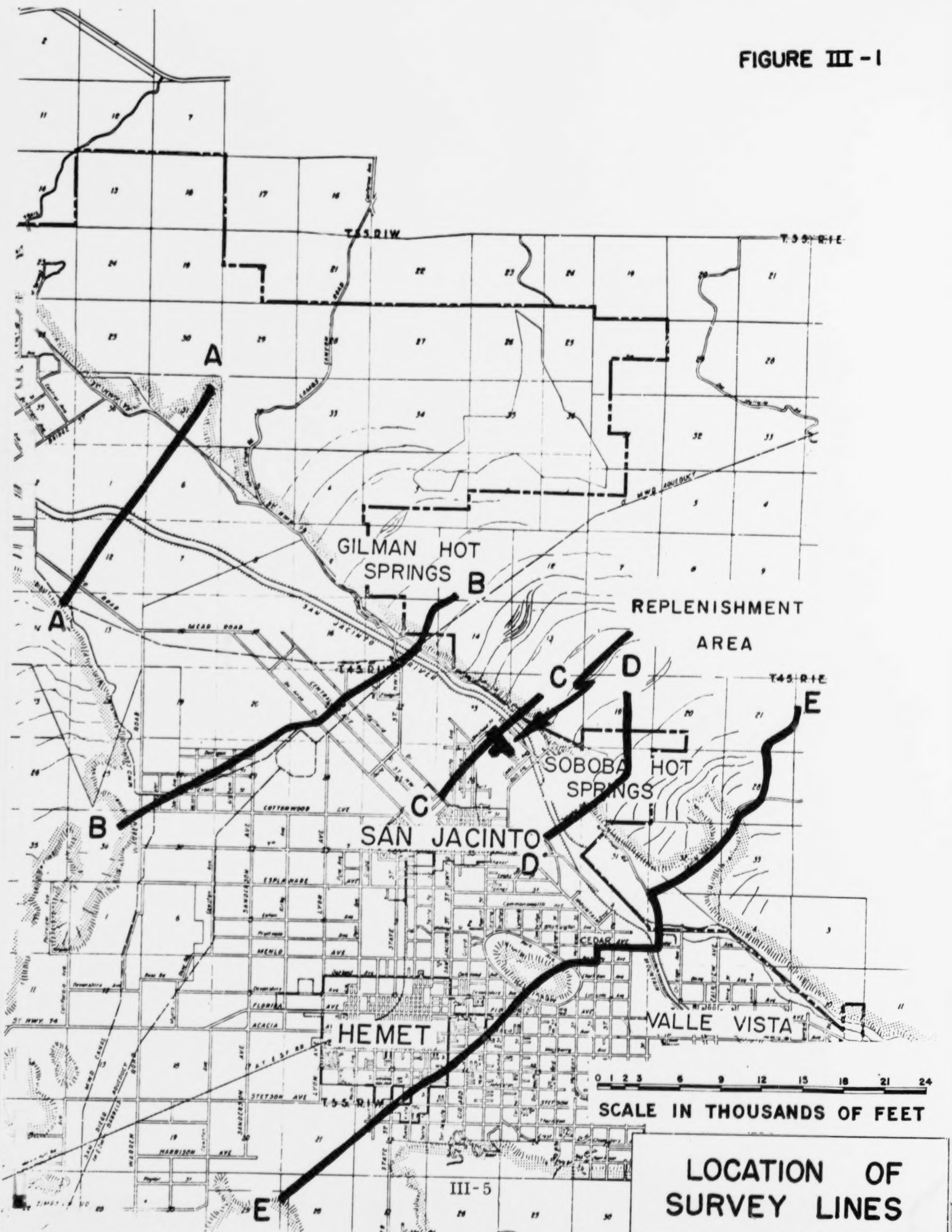
V_0 = 1,300 fps, Thickness = 30' - 35'
V_1 = 5,000 - 5,750 fps, Thickness = 1,095' - 1,115'
V_2 = 7,200 - 7,350 fps, Thickness = 1,930' - 2,100'
V_3 = 8,650 - 8,850 fps, Thickness = 2,000' - 3,000'
V_4 = 10,150 - 11,500 fps, Thickness = 5,400' - 7,000'
V_5 = 16,000 - 18,500 fps, bedrock at minimum depth of 10,400'± 1000 feet.

The reversal of Line A indicated somewhat less depth to bedrock. It showed bedrock at a depth of 8,400 feet approximately 1-1/2 miles southeast of the location established from Shot Point 1. This difference could be attributed to either a dip in bedrock surface of approximately 12 degrees to the northwest or a misinterpretation of the depth to ground water. This could be clarified by further testing, but for the purpose of the project the bedrock depth of 8,400 feet or greater is sufficiently accurate.

Three other seismic lines were investigated and these lines are designated Lines B, C and D and shown on Figure III-2.

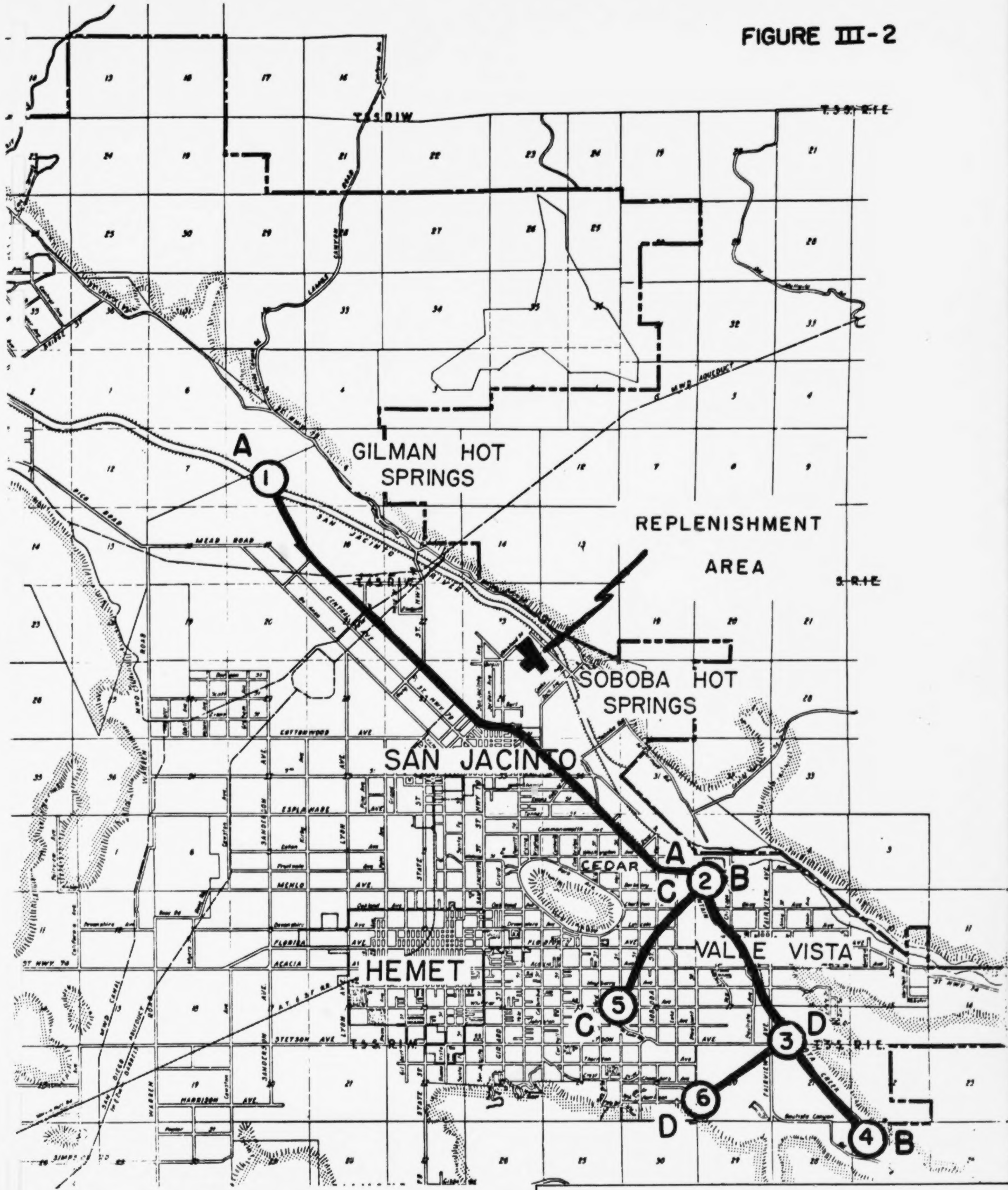
Figure III-3 is a block diagram of the San Jacinto Valley based on the seismic surveys and past investigations of others.

FIGURE III-1


A
A
B
B
C
C
D
D
E
E
GILMAN HOT SPRINGS
REPLENISHMENT AREA
SOBOBA HOT SPRINGS
SAN JACINTO
HEMET
VALLE VISTA
CEDAR AVE
T5S R1W
T5S R1E
T4S R1W
T4S R1E
SAN JACINTO RIVER
MWD AQUEDUCT
MEAD ROAD
COTTONWOOD AVE
ESPLANADE AVE
MENLO AVE
FLORIDA AVE
ACACIA
STETSON AVE
HARRISON AVE
SANDERSON AVE
LYON AVE
STATE ST
0 1 2 3 6 9 12 15 18 21 24
SCALE IN THOUSANDS OF FEET

LOCATION OF SURVEY LINES

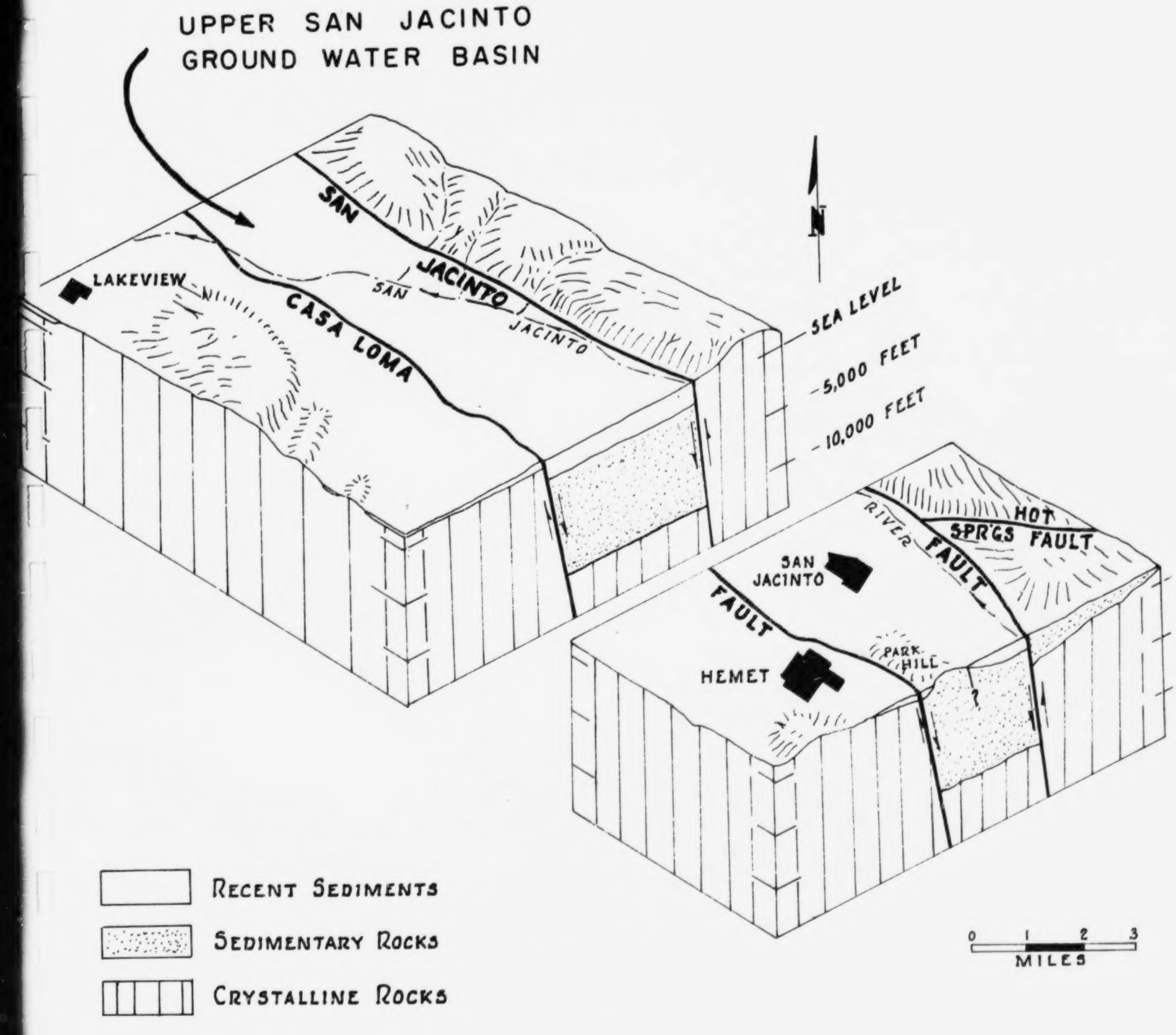
FIGURE III-2


T.4S.R1W
T.4S.R1E
A
1
GILMAN HOT SPRINGS
REPLENISHMENT AREA
T.5S.R1W
S.R1E
SOBOBA HOT SPRINGS
SAN JACINTO
CEDAR
A
C
2
B
VALLE VISTA
HEMET
5
C
3
D
T.5S.R1W
T.5S.R1E
6
D
4
B
MWD AQUEDUCT
SAN JACINTO RIVER
MEAD ROAD
COTTONWOOD AVE
ESPLANADE
MENLO AVE
FLORIDA AVE
ACACIA
STETSON AVE
HARRISON AVE
0 1 2 3 6 9 12 15 18 21 24

SCALE IN THOUSANDS OF FEET

LOCATION OF SEISMIC SURVEY LINES

FIGURE III-3


UPPER SAN JACINTO GROUND WATER BASIN
LAKEVIEW
SAN JACINTO
CASA LOMA
SAN JACINTO
SEA LEVEL
-5,000 FEET
-10,000 FEET
N
RIVER
HOT SPR'GS FAULT
FAULT
SAN JACINTO
FAULT
PARK HILL
HEMET
?
RECENT SEDIMENTS
SEDIMENTARY ROCKS
CRYSTALLINE ROCKS
0 1 2 3
MILES

AFTER FETT 1968, AND PROCTOR 1968

BLOCK DIAGRAM OF THE SAN JACINTO VALLEY

CHAPTER IV

SAFE YIELD OF THE UPPER SAN JACINTO GROUND WATER BASIN

Past investigations of water use(4) and the safe yield of the San Jacinto Valley area(5), (6), (7) have dealt with the hydrologic areas as defined by the California Department of Water Resources. Since the Replenishment Area is in the Upper San Jacinto Ground Water Basin which, along with its watershed, comprise the San Jacinto Hydro Sub-unit it will be the area under discussion here. Although a portion of the Hemet Hydro Sub-area could theoretically be included as it surficially drains into the San Jacinto unit, it will be excluded here as:

1. It is not part of the hydrologic unit by designation,
2. It is dubious if any appreciable amount of subsurface flow can enter the San Jacinto unit from it due to the Casa Loma Fault,
3. The bulk of the area is valley floor and any runoff is undoubtedly not appreciable. The excluded area is denoted on Figure IV-1 along with the boundaries of the Upper San Jacinto Ground Water Basin and its watershed.

To calculate the safe yield of this ground water basin, a great deal of hydrologic data had to be collected and assimilated. The major sources of information were:

1. United States Weather Bureau
2. United States Coast and Geodetic Survey
3. State of California, Department of Water Resources
4. Riverside County Flood Control and Water Conservation District, Riverside, California

Precipitation

Approximately 35 precipitation stations have existed at one time or another in or near the Upper San Jacinto Ground Water Basin and Watershed. Of these, 20 stations were selected as suitable for this study. The locations of these stations are shown on Figure IV-2 while a complete tabulation of the precipitation data is presented in Table IV-1. It is felt that Table IV-1 represents the most complete set of precipitation data up to 1965 that is now available. For purposes of this study the term fiscal year is defined as the period July 1 to June 30.

In order to calculate the safe yield, it is necessary to select a suitable base or reference period. Long-term precipitation records provide a convenient means of establishing such a period. The cumulative deviation from the long-term mean precipitation was computed for five separate stations. Based on this information, the 38-year interval beginning with the fiscal year 1922-23 and ending with the year 1959-60 was selected as the base period. The mean precipitation for this period closely approximates the long-term mean for the entire period of record.

Mean precipitation values for the base period have been calculated and are given in Table IV-1. By comparison with nearby stations, mean values for stations with incomplete records were extrapolated. Using the mean values for the base period, isohyets were drawn and are shown in Figure IV-2. The average yearly rainfall on the total basin and the basin floor were, in turn, determined and are presented in Table IV-2. Of particular importance in the calculation of safe yield is the average precipitation on the ground water basin, 39, 220 acre-feet per year.

Surface Runoff

Surface runoff from the surrounding watershed constitutes a major source of water inflow to the Upper San Jacinto Ground Water Basin. There is also occasionally a significant quantity of water leaving the basin as surface flow. Unfortunately, only limited data on stream flow exist for this area. Using such information as is available, the surface inflow to and outflow from the ground water basin can be calculated as discussed below.

(a) Surface Inflow

A number of streams debouche upon the San Jacinto Basin floor. The principal one is the San Jacinto River. A continuous record of the stream flow at Cranston Bridge is available for the period 1920-21 to the present as shown in Table IV-3. Immediately above the gaging station, however, a portion of the river flow is diverted to Lake Hemet Municipal Water District's water system. A portion of this water does reach the Basin floor as irrigation and domestic water and the balance is exported. In this report the diverted, but not exported, water will be included in the computations as surface runoff into the basin.

Limited stream flow data, included in Table IV-3, exist for Bautista, Indian, Potrero and Poppet Creeks. Mean flow values over the base period 1922-23 to 1959-60 for these streams were extrapolated by comparison with the stream flow in the San Jacinto River above the diversions; i. e., San Jacinto River gaging station flow plus diverted flow.

Most of the surface runoff into the Upper San Jacinto Ground Water Basin is represented by the flow in the five streams cited above. Areas exist, however, that are not tributory to these five streams. To delineate these areas, the runoff areas for the five streams have been determined and the

the entire basin divided into 11 segments as shown on Figure IV-3. Runoff coefficients were calculated for four of the five runoff areas for which rainfall and stream flow data were available. These coefficients were then applied to adjacent areas to obtain values for the runoff as shown in Table IV-4.

The mean runoff reaching the basin floor, therefore, is seen to be 28, 590 acre-feet per year for the base period 1922-23 to 1959-60. Of this amount, 19, 160 acre-feet per year is attributable to the San Jacinto River.

(b) Surface Outflow

The major surface runoff out of the ground water basin occurs near the northwestern end of the basin through the San Jacinto River. Farther west on this river, a gaging station was operated at Elsinore from 1916-1951 and another at Railroad Canyon Dam from 1952 to 1960. Data collected from these stations are presented in Table IV-5 with allowances being made for evaporation from Railroad Reservoir from 1927 to 1960 and diversions by Temescal Water Co.

Unusual accretions occurring during the construction of the San Jacinto Tunnel are not included in these values. It appears reasonable to combine the data from the two stations to obtain coverage for the base period 1922-23 to 1959-60 and by so doing, the mean flow is found to be 9, 015 acre-feet per year. It was assumed by Fritz and Rosell and will be assumed here that 95% of 8, 565 acre-feet per year of the flow at Elsinore originated in the San Jacinto basin.(5)

Imports and Exports of Water

Water has been imported to the Upper San Jacinto Ground Water Basin through the San Jacinto tunnel since 1941-42. Records of the Eastern Municipal Water District are summarized in Table IV-6. During the period 1941-42 to 1959-60, the mean import was 1, 930 acre-feet per year.

The water that entered the basin during the tunnel construction years of 1932 to 1939 has been essentially ignored, based on the following:

1. Its origin is not known and therefore whether it is an export or import is not known;
2. A great portion of it occurred in 1938, a year of high seasonal runoff and therefore any percolation would be minimized;
3. The ground water level was high or artesian in the area of entry and therefore percolation would be negligible;
4. The proximity to the river bed and silty-clay soil which helped to readily move the water out of the basin and also to prevent percolation,(4)
5. The general lack of agricultural provisions to utilize the varying flow.

Consumptive Water Use

One of the major items to be considered in any water balance is the loss of water through consumptive use. The total water used in plant growth, transpiration from the plant surfaces and evaporation from the soil surface, depends on the geographical location and the land use. The California Department of Water Resources made a land use survey in 1964 for the entire Upper Santa Ana River drainage area(7) and from this information Table 7, a tabulation of the land use categories for the Upper San Jacinto Ground Water Basin was prepared. Unit values for consumptive use for this area were obtained from the report entitled "Santa Ana River Investigation".(8) For the basin floor area of 37,000 acres, the total consumptive use is calculated to be 61,830 acre-feet per year.

For the calculation of the safe yield, information on the total consumptive use of the basin is not sufficient. It is necessary to know how much of the precipitation runoff and imports entering the basin is consumptively used. This consumption constitutes only one part of the total consumptive use. The remainder represents consumptive use of water originating in the basin as groundwater and pumped to the surface for irrigation, water supplies, etc.

Two approaches can be used to calculate the partial consumptive use. The first method requires a detailed knowledge of storm intensity, duration, and frequency, temperature, open water surface areas during spreading and irrigation operations, percolation rates, and so forth. Such information is only partially available for the Upper San Jacinto Ground Water Basin.

The second method involves comparing unit consumptive use values with the mean precipitation. For the base period, the mean precipitation for the entire valley is found to be on the order of 1.06 feet/year. Where the unit consumptive use values exceed this mean precipitation it is assumed that none of the precipitation reaches groundwater storage. Rather, it is all consumptively used. In two instances, the unit consumptive use values are less than the mean precipitation. The difference is assumed to represent accretion to the groundwater storage. As determined earlier, the mean precipitation on the basin floor was 39,220 acre-feet per year. Of this quantity, the consumptive use is calculated in Table IV-7 to be 38,643 acre-feet/year.

It should be recognized that deep penetration of precipitation is not dependent only on yearly averages, but is a function of storm intensity, duration, and frequency and other climatic conditions. In the Hemet-San Jacinto area, the influence of these factors on groundwater accretions is quite small and can be neglected. Similarly, the small amount of consumptive use from runoff and other surface waters entering the valley will be neglected.

On this basis, the total consumptive use of water entering the valley is calculated to be 38,643 acre-feet/year.

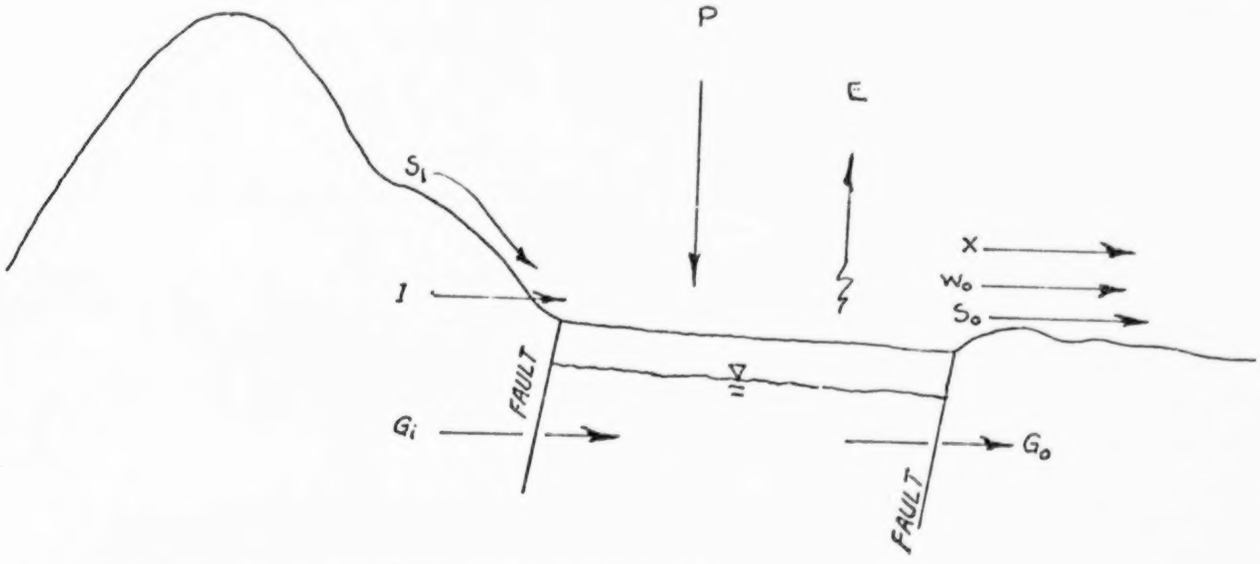
Ground Water Flow

Sub-surface flow is of little consequence in the safe yield calculation for this basin. The restriction to sub-surface flow both in and out of the basin due to faults and bordering sediments of high impermeability is made evident by records of water well levels as mentioned in Chapter II. If there has been any sub-surface inflow within the last 19 years caused by the reversal of ground water gradients due to the basin being overdrafted, it is assumed here to be comparable to the amount that possibly outflowed during the 19 years prior to that. Recent surveys by the California Department of Water Resources indicate a net inflow of 500 acre-feet/year. With these facts in mind, the net ground water flow during the base period was assumed to be zero.

The Safe Yield Calculation

The concept of safe yield has fallen into disrepute perhaps as a result of the many different definitions proposed for the term. When properly used, however, the safe yield can be a valuable piece of information. For this report, the safe yield is defined as the annual rate at which water can be withdrawn from a groundwater basin without producing a permanent overdraft.

To further elucidate this concept, an equation for safe yield can be derived. Consider the following cross-section of a typical drainage basin,



where: S_i = surface inflow (runoff)
S_o = surface outflow (runoff)
I = imported water
X = exported water
P = precipitation
E = consumptive use (primarily evapotranspiration)
W_o = wastewater outflow
G_i = subsurface inflow
G_o = subsurface outflow

The change in the total groundwater storage, $\triangle GS$, can be defined as:

$$\triangle GS = (P+S_i+I+G_i) - (S_o+E+X+W_o+G_o)$$

With the information developed earlier, the mean change in the groundwater storage for the Upper San Jacinto Ground Water Basin can be calculated thus:

P = 39, 220 acre-feet/year
S_i = 28, 590
I = 1, 930
G_i = 0
Inflow 69, 740 acre-feet/year

S_o = 9, 015
E = 61, 830
X = 10, 877
W_o = 0
G_o = 0
Outflow 81, 722 acre-feet/year

Mean change $\triangle GS$ = 11, 982 acre-feet/year

It is readily apparent that a large overdraft has been occurring for many years from the Upper San Jacinto Ground Water Basin.

The equation for the safe yield differs only slightly from the equation for $\triangle GS$. In order to establish the safe yield equation, one additional step is necessary. As developed earlier the consumptive use can be divided into two segments: first, consumptive use of precipitation imports and runoff entering the basin and, second, consumptive use of groundwater pumped to the basin surface, or by the formula

$$E = E_p + E_g$$

where: E = total consumptive use = 61, 830
E_p = consumptive use of precipitation, runoff & imports = 38, 643
E_g = consumptive use of pumped groundwater. = 23, 187

The equation for the safe yield can now be written as:

$$\text{Safe yield} = (P + S_i + I + G_i) - (S_o + E_p + X + G_o)$$

or, substituting for $\triangle GS$:

$$\text{Safe yield} = \triangle GS + E_g + W_o$$

Finally, the safe yield can be calculated:

P = 39, 220 acre-feet/year
S_i = 28, 590
I = 1, 930
G_i = 0
Inflow 69, 740 acre-ft. /yr.

S_o = 9, 015
E_p = 38, 643
X = 10, 877
G_o = 0
Outflow 58, 535 acre-ft. /yr.

Safe yield = 11, 205 acre-feet/year

Thus, the safe yield of the Upper San Jacinto Ground Water Basin is found to be 11, 205 acre-feet/year.

TABLE IV -1
PRECIPITATION RECORDS
(inches)

Fiscal Year Ending	San Jacinto 1	Hemet 2	Winchester 3	Lakeview 4	Morreno (Erramuspe) 5	Anza 6	Hemet Reservoir 7	Idyllwild Ranger Station 8	Decker's Ranch 9	Simm's Ranch 10
1910	12.52			11.33			19.98	25.35		
1	15.44	14.73		12.14			21.17	27.82		
2	12.64	12.48		12.02			17.68	22.14		
3	8.62	12.21		7.30			14.10	19.95		
4	18.87	21.58		15.71			24.38	37.31		
15	18.09	24.00		19.48			27.27	30.11		
6	16.60	19.69		14.77			25.44	31.41		
7	11.45	12.99		10.13			17.34	29.38		
8	12.27	15.24		12.60			16.57	30.85		
9	10.25	9.14		8.95			15.78	24.05		
1920	14.61	13.86		13.39			23.83	29.40		
1	10.82	11.41		9.58			15.23	20.82	31.78	
2	25.23	25.76		26.44	25.77		34.71	52.79	56.99	
3	10.68	9.06		10.91	9.93		20.10	20.76	30.35	
4	9.74	8.66		10.29	9.20		14.20	17.10	26.31	
25	7.28	6.99		7.60	7.91		14.13	15.65	28.45	
6	16.69	14.05		17.31	15.86		25.18	27.00	46.42	
7	19.37	18.41		17.95	18.54		30.86	35.31	60.92	
8	9.44	9.12		10.29	10.24		13.53	22.05	22.63	
9	9.19	8.70		8.11	9.36		12.54	17.76	27.56	
1930	15.10	14.99		15.40	14.71		28.27	29.75	37.40	
1	8.87	9.62		10.16	11.88		11.99	18.75	23.78	
2	19.54	18.98		16.72	18.61		27.61	45.04	48.92	
3	9.94	10.12		12.04	9.47		11.95	20.40	26.56	
4	6.36	6.64		5.77	6.31		6.12	14.91	21.37	
35	15.91	15.18		15.22	17.28		20.56	35.21	36.67	
6	10.07	9.19		9.24	9.12		16.87	17.87	34.68	
7	24.62	24.98		23.58	25.44		31.34	43.96	61.20	
8	14.84	13.35		14.86	15.34		25.53	28.26	45.49	21.02
9	12.88	11.32		12.44	12.23		15.42	25.25	31.08	14.87
1940	16.23	13.65			13.17		21.12	32.91	36.33	21.08
1	24.63	23.73	20.17		24.02		31.95	47.06	64.06	24.33
2	12.26	10.68	9.33		10.98		16.78	26.61		12.09
3	15.46	14.14	12.86		16.55	17.30	23.90	26.69		19.62
4	13.49	12.84	12.07		13.77	16.41	16.18	25.13		14.86
45	12.49	12.52	12.05		11.56	13.80	16.54	22.40		15.12
6	12.39	7.81	9.69		6.29	14.71	21.46	18.73		13.62
7	11.62	10.88	8.86		11.10	13.67	18.29	23.29		14.96
8	7.55	6.44	6.86		8.13	9.77	13.87	19.06		8.44
9	9.45	8.96	8.85		9.22	9.39	13.52	22.78		15.17
1950	7.13	7.17	6.85		8.91	8.26	13.01	19.87		9.59
1	7.27	6.38	4.44		6.39	7.29	10.58	12.80		10.55
2	18.22	17.67	11.89		20.35	23.79	27.58	41.03		24.97
3	11.59	10.16	9.26			11.62	14.94	21.46		13.45
4	10.84	10.02	9.26			10.60	16.14	25.03		14.19
55	11.74	9.88	9.01			8.61	13.50	18.74		15.74
6	6.94	6.13	12.11			7.72	11.18	21.81		9.19
7	10.75	9.45	15.07			9.63	13.58	21.47		12.70
8	24.94	19.10	19.24			20.21	28.34	38.31		25.61
9	6.98	7.31	5.19			5.81	9.51	12.40		5.83

continued

TABLE IV - 1 (continued)

Fiscal Year Ending	San Jacinto 1	Hemet 2	Winchester 3	Lakeview 4	Morreno (Erramuspe) 5	Anza 6	Hemet Reservoir 7	Ranger Station 8	Decker's Ranch 9	Simm's Ranch 10
1960	9.99	8.56	7.29			13.31	17.34	22.76		13.20
1	3.71	3.90	3.66			5.30	6.56	8.38		5.69
2	11.27	11.29	10.21			12.26	15.80	22.48		12.84
3	6.88	6.70	6.34			7.57	11.15	14.90		
4	12.05	12.13	9.90			15.13	18.84	26.37		
65	9.64	9.25				10.55		25.29		
Total 1923-1960	482.48	442.84	421.59*	465.59*	462.05*	517.01*	695.50	955.37	1308.96*	572.24*
Mean 1923-1960	12.70	11.65	11.09*	12.25*	12.16*	13.61*	18.30	25.14	34.45*	15.06*

* Extrapolated

continued

TABLE IV - 1 (continued)

Fiscal Year Ending	Poppet Flats 11	Snow Creek 12	Twin Pines 13	Beaumont 14	Banning 15	Reche Canyon 16	Beaumont Pumping Plant 17	Cabazon 18	Railroad Canyon Dam 19	March Field 20
1910				14.49						
1				19.89						
2				17.56			19.34			
3				10.23			11.91			
4				27.48			31.90			
15				28.61			27.90			
6				26.19			31.95			
7				19.44	14.45		25.07			
8				17.08	16.76		19.50			
9				15.68	13.93		14.98			
1920		16.51	26.79	22.93	20.65	16.03	27.23			
1		9.57	16.29	16.88	15.37	11.05	23.65			
2		24.30	34.04	32.89	30.05	27.24	36.43			
3		8.64	18.48	17.21	14.30	11.72	20.12			
4		7.59	14.40	13.77	13.40	9.64	16.48			
25		6.82	14.96	13.29	10.81	12.25	18.19			
6		14.18	26.19	24.52	23.03	17.69	26.16			
7		17.19	31.24	27.75	24.50	17.31	30.84			
8		7.34	10.33	13.16	11.82	12.21	16.01		3.39	
9		6.40	18.44	13.94	12.70	11.44	15.24		6.56	
1930		11.73	21.32	21.92	17.74	16.22	21.95		15.73	12.64
1		7.05	13.61	13.81	11.84	13.21	16.64		9.68	10.25
2		22.78	29.75	26.03	25.36	19.12	27.50		16.62	12.34
3		8.81	13.25	15.36	13.41	9.56	17.77		9.67	6.97
4		5.26	10.75	11.75	10.77	9.13	12.71		7.90	3.53
35		12.69	22.35	20.53	18.64	16.28	21.86		14.89	11.38
6		7.78	20.01	15.65	15.59	12.53	20.64		7.78	6.44
7		22.55	36.06	34.00	31.78	27.78	38.19		20.95	18.62
8	31.19	21.20	29.73	22.89	20.88	17.55	28.95		16.53	11.25
9	20.22	10.97	18.62	18.20	14.54	12.24	18.12		11.80	11.73
1940	29.45	13.96	21.73	22.53	19.66	16.01	22.21	10.43	12.40	
1	40.24	24.74	34.50	30.25	30.04	25.52	33.61	23.86	23.84	21.62
2	17.87	10.72	15.24	14.44	14.42	11.59	17.33	9.33	8.89	9.27
3	28.95	19.59	29.87	23.79	21.51	19.45	29.99	17.71	13.33	10.25
4	21.03	15.94	25.97	20.08	17.56	18.06	20.59	11.98	15.18	13.57
45	23.91	10.81	19.85	19.16	15.37	13.35	20.70	11.13	9.94	8.94
6	18.87	12.87	19.23	15.39	15.62	10.58	18.98	12.71	7.29	7.04
7	28.89	10.43	15.78	17.64	17.48	12.27	20.28	10.64	7.98	8.60
8	13.86	6.95	11.62	11.54	9.72	8.71	12.84	7.60	3.86	5.04
9	16.35	9.77	18.48	14.63	15.20	11.39	17.93	5.93	6.75	5.66
1950	18.05	6.48	13.26	12.93	11.47	10.55	15.67	4.72	3.66	6.06
1	12.54	4.90	10.56	9.34	9.10	7.76	12.33	6.25	5.15	4.67
2	29.71	19.66	35.98	23.66	24.71	23.56	26.69	19.45	14.81	17.48
3		12.18	20.11	14.00	14.24	12.76	16.37	12.69	8.21	10.39
4		12.88	20.48	17.75	15.48	9.46	20.45	12.21	8.79	10.70
55		11.61	14.84	14.13	14.01	12.31	15.74	11.68	8.61	9.86
6		6.61	11.49	12.07	10.80	10.77	18.47	11.62	5.55	6.58
7		8.92	17.13	14.71	13.60	10.98	17.18	11.01	8.36	8.80
8		21.68	31.85	27.32	27.71	18.64	28.06	23.03	16.08	15.04
9		10.90	12.49	9.21	8.30	5.56	10.01	10.12	3.96	4.68

continued

TABLE IV - 1 (continued)

Fiscal Year Ending	Poppet Flats 11	Snow Creek 12	Twin Pines 13	Beaumont 14	Banning 15	Reche Canyon 16	Beaumont Pumping Plant 17	Cabazon 18	Railroad Canyon Dam 19	March Field 20
1960		9.31	17.13	13.37	12.43	10.38	14.71	8.98	8.13	6.36
1		5.15	9.98	7.75	6.02	3.92	8.49	4.40	7.38	2.32
2		11.61	24.17	17.03	15.84	12.89	19.86	13.11	11.26	7.83
3		6.40	11.79	8.73	8.97	8.02	10.69	7.54	5.80	4.74
4		14.12	25.23	17.05	15.58	15.45	18.37	14.43	7.75	
65		8.65	19.59	14.49	14.14	11.48	18.02	10.23	9.31	
Total 1923-1960	840.57*	459.89	767.08	681.72	629.54	525.55	777.51	488.47*		
Mean 1923-1960	22.12*	12.10	20.19	17.94	16.57	13.83	20.46	12.85*		

* Extrapolated

TABLE IV-2

AVERAGE PRECIPITATION FOR THE BASE PERIOD

Precipitation, inches		Area, acres		Annual Precipitation, acre-feet/year	
Range	Average	Total Basin	Basin Floor	Total Basin	Basin Floor
11-12	11.5	100	100	100	100
12-13	12.5	26,785±	26,650±	28,010	27,715
13-14	13.5	14,790±	3,310±	16,640	3,725
14-15	14.5	21,520	2,200±	22,530	2,660
15-16	15.5	31,480	2,220±	40,605	2,870
16-17	16.5	33,490	950	46,050	1,310
17-18	17.5	25,700	430	37,480	630
18-19	18.5	17,480	70	26,950	110
19-20	19.5	13,050		21,210	
20-21	20.5	10,000		17,080	
21-22	21.5	8,440		15,120	
22-23	22.5	6,190		11,610	
23-24	23.5	5,470		10,710	
24-25	24.5	4,660		9,510	
25-26	25.5	3,850		8,180	
26-27	26.5	3,160		6,980	
27-28	27.5	2,880		6,600	
28-29	28.5	2,380		5,650	
29-30	29.5	2,010		4,940	
30-31	30.5	1,520		3,860	
31-32	31.5	1,360		3,570	
32-33	32.5	1,010		2,740	
33-34	33.5	460		1,280	
34-35	34.5	70		200	
Totals		240,000±	37,000±	347,665	39,220

TABLE IV-3

STREAM FLOW INTO UPPER SAN JACINTO GROUND WATER BASIN

(Acre-Feet)

Fiscal year ending	San Jacinto River, Cranston Bridge			Bautista Creek	Indian Creek	Potrero Creek	Poppet Creek
	Gaging station	Diversions	Total				
1920							
21	5,240						
22	55,400	12,264	67,664				
23	11,640	11,299	22,939				
24	3,920	23,320	27,240				
1925	740	4.170	4,910				
26	17,980	13,850	31,830				
27	26,840	10,110	36,950				
28	5,070	11,100	16,170				
29	3,410	8,980	12,390				
1930	7,260	12,370	19,630				
31	1,070	5,180	6,250				
32	28,610	11,410	40,020				
33	2,180	8,640	10,820				
34	820	7,790	8,610				
1935	5,120	6,010	11,130				
36	8,040	10,270	18,310				
37	94,410	12,770	107,180		12,420	16,300	5,860
38	58,730	12,610	71,340		9,260	8,040	4,000
39	9,400	11,970	21,370		2,260	1,720	550
1940	8,150	10,620	18,770		2,180	860	740
41	55,350	10,630	65,900		7,770	1,840	3,490
42	7,540	13,200	20,740		1,820		

continued

TABLE IV-3 (continued)

Fiscal year ending	San Jacinto River, Cranston Bridge Gaging station	 Diversions	 Total	Bautista Creek	Indian Creek	Potrero Creek	Poppet Creek
1943	23,780	1,490	25,270		1,970		
44	7,020	1,220	8,240				
1945	14,750	1,300	16,050				
46	4,620	870	5,490		990		
47	2,550	460	3,010		1,020		
48	320	500	820	10	440		
49	3,070	3,650	6,720	0	1,710		
1950	1,710	1,940	3,650	0			
51	40	810	850	0			
52	24,340	1,650	25,990	2,920			
53	3,120	1,230	4,350	0			10
54	6,560	370	6,930	350			
1955	1,070	1,210	2,280	20			
56	1,750	910	2,660	350			
57	1,070	4,030	5,100	0			
58	31,010	7,080	38,090	2,600			
59	2,320	3,550	5,870	60			
Total Mean 1922-23 to 1959-60	12,810	6,647	19,457	1,020*	2,310*	1,940*	970*

* Extrapolated by comparison with total flow of San Jacinto River into basin

TABLE IV-4

SURFACE RUNOFF FROM AREAS TRIBUTORY TO UPPER SAN JACINTO GROUND WATER BASIN

Area number(a)	Stream	Tributory Mean rainfall(b) ac-ft	Mean stream flow(c) ac-ft	Runoff coeff.(d)	Mean runoff(c) ac-ft
I	-	23,290	-	-	1,425
II	Potrero	31,960	1,940	0.0607	1,940
III	-	6,280	-	-	385
IV	Poppet	15,760	970	0.0616	970
V	-	900	-	-	55
VI	Indian	-	2,310	-	2,310
VII	-	2,360	-	-	225
VIII	San Jacinto	147,770	19,160	0.1297	19,160
IX	-	6,530	-	-	845
X	Bautista	37,490	1,020	0.0272	1,020
XI	-	2,075	-	-	255
Totals			25,400		28,590

(a) See Fig. IV-3 for location of areas

(b) By planimeter

(c) For base period 1922-23 to 1959-60

(d) Ratio-stream flow: rainfall

TABLE IV-5

STREAM FLOW OUT OF UPPER SAN JACINTO GROUND WATER BASIN

(Acre-Feet)

Fiscal year ending	San Jacinto River Elsinore		Railroad Canyon Dam *
1923	670		
1924	200		
1925	80		
1926	11,960		
1927	83,400		
1928	960		
1929	690		
1930	2,710		
1931	960		
1932	12,060		
1933	650		
1934	20		
1935	240		
1936	0		
1937	78,610		
1938	38,010		
1939	5,980		
1940	1,120		
1941	54,010		
1942	540		
1943	14,330		
1944	4,200		
1945	2,330		
1946	520		
1947	270		
1948	30		
1949	10		
1950	0		
1951	0		
1952			12,770
1953			950
1954			960
1955			390
1956			1,260
1957			720
1958			8,770
1959			50
1960			0
Subtotals	313,870	+ 2900**	25,870
Total		342,640***	
Mean 1922-23 to 1959-60		9,015***	

* Adjusted to include diversions and evaporation from Reservoir

** Estimated loss of 100 acre-feet per year due to consumptive use by vegetation & percolation loss in 2 mile riverbed area from Railroad Reservoir Station to Elsinore Sta. during 29 year period 1922-23 to 1950-51. See pg. 128 of (4)

*** Combined to give record for entire period.

TABLE IV-6

IMPORTS AND EXPORTS OF THE UPPER SAN JACINTO GROUND WATER BASIN

Fiscal Year Ending	Exported Water Acre-feet				Imported MWD Water Acre-feet	
	L.H.M.W.D.		Fruitvale	Others	Others	E.M.W.D
	Diversions	Wells				
1922-23						
24						
25	3,850		5,700			
26		150(a)				
27	1922-23	425	1922-23			
28	to	190	to			
29	1938-39	260	1938-39			
1930	50% of mean	185				
31	diversion	245	80% of			
32	estimated	65	mean pro-			
33	as export	125	duction			
34		310	estimated			
35	see pg.116	310	as export			
36	of (4)	265				
37		210	see pg.			
38		185	205 of (4)			
39		180				
1940	5,320(b)	160	5,700(e)			
41	5,320	250	5,700			
42	6,600	180	5,700		120	
43	745	385	5,700		1,960	
44	610	380	6,770		2,060	
45	650	420	6,770		1,290	
46	435	480	6,770		870	
47	230	480(a)	6,770		260	
48	250		7,840		70	
49	1,825	estimated @530 AF/yr(c)	7,840		30	

Continued

TABLE IV-6 (cont)

IMPORTS AND EXPORTS OF THE UPPER SAN JACINTO GROUND WATER BASIN

Fiscal Year Ending	Exported Water Acre-feet				Imported MWD Water Acre-feet	
	L.H.M.W.D.		Fruitvale	Others	Others	E.M.W.D.
	Diversions	Wells				
1950	970	estimated @530	7,840		570	
51	405	AF/yr(c)	7,840		1,050	
52	825	↓	8,920		860	
53	615		8,920			780
54	185		8,920(e)			250
55	605	5,750(d)	9,110(f)			2,400(g)
56	455	1,580	8,770	298		3,900
57	2,015	3,080	6,800	298		6,000
58	3,540	3,610	5,770	468		3,700
59	1,725	4,460	7,860	471		4,900
1960	2,045(b)	3,310(d)	8,760(f)	424		5,550(g)
Total	100,820	31,340	263,560	1,959	9,140	27,480
Mean	2,653	896	6,936	392	832	3,440
Total of Means-Exported Water			10,877	Mean of total Imported Water		1,930

(a)
(b) Based on estimate of 50% of diversions exported 1939-40 to 1959-60
(c) 25% of Mean of ave. from 1925-26 to 1946-47 (1,043) & ave. from 1954-55 to 1967-68 (3,185)
(d) Based on estimate of 75% of production exported 1954-55 to 1959-60
(e) 1939-1940 to 1953-1954 estimated by R. K. Morton
(f) 1955-56 to 1959-60 based on 80% export as per G. Black of Fruitvale as per 1967-67 production and export data
(g) 1954-55 to 1959-60 estimated by R. K. Morton based on EMWD records and 1958-59 delivery data

TABLE IV-7

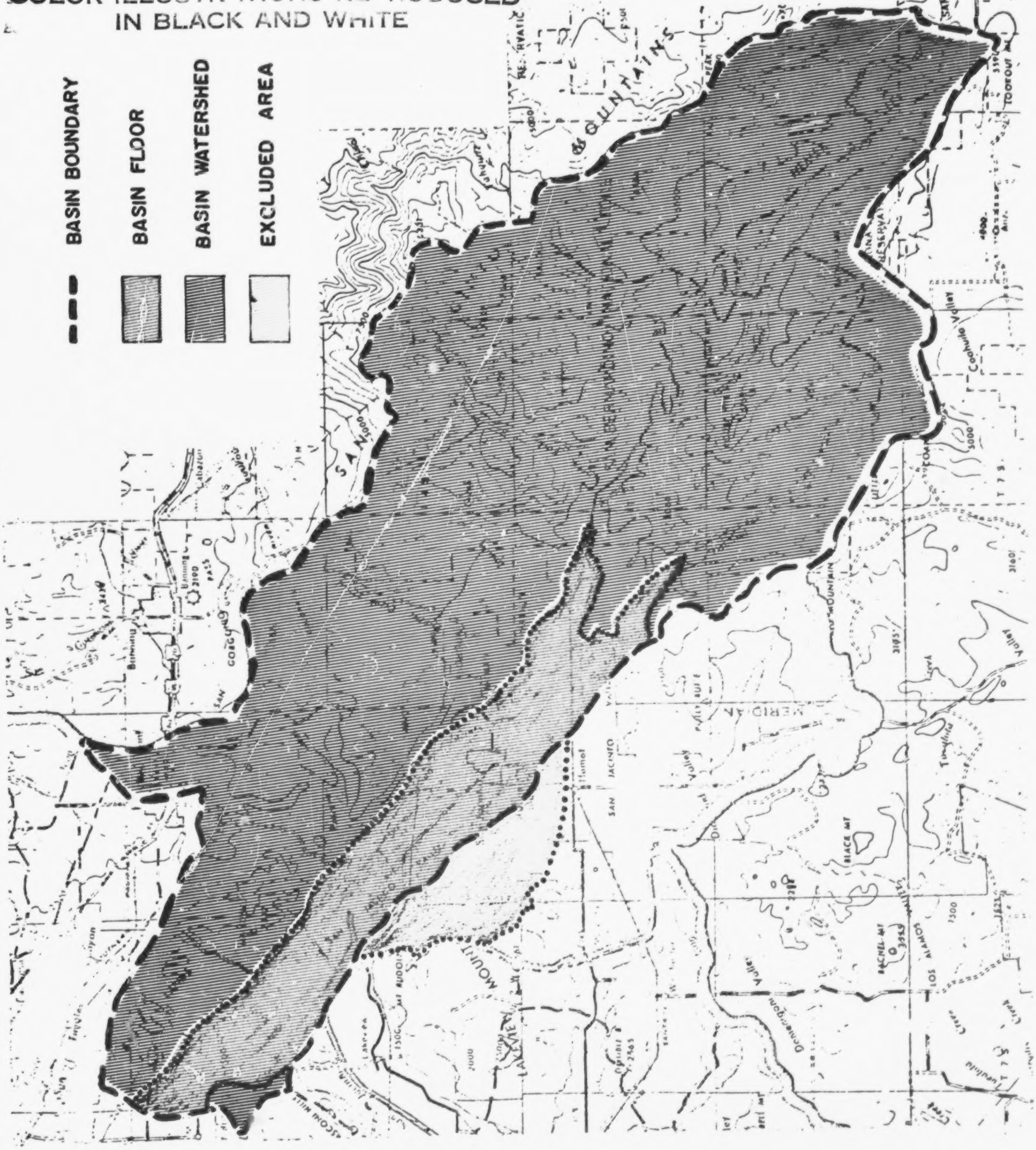
CONSUMPTIVE WATER USE

Land Use Category	Area Acres	Total Consumptive Use Unit Value Feet	Total Consumptive Use Total Acre-feet	Consumptive Use-rainfall only* Unit Value Feet	Consumptive Use-rainfall only* Total Acre-feet
1. Water service area					
a. Urban and suburban					
Residential	1,990	1.43	2,846	1.06	2,109
Recreational residential	1,150	3.00	3,450	1.06	1,219
Commercial	430	0.71	305	0.71	305
Industrial	20	7.14	145	1.06	21
Unsegregated urban and suburban	1,150	1.19	1,368	1.06	1,219
Included nonwater service area	2,460	1.10	2,706	1.06	2,608
Gross urban and suburban	7,200		10,820		7,481
b. Irrigated agriculture					
Alfalfa	1,380	3.83	5,285	1.06	1,463
Pasture	1,730	3.83	6,626	1.06	1,834
Citrus and subtropical	1,810	2.62	4,742	1.06	1,919
Truck crops	440	1.41	620	1.06	466
Field crops	0	1.41	0	1.06	0
Desiduous fruits and nuts	1,920	2.32	4,454	1.06	2,035
Small grain	2,270	1.41	3,201	1.06	2,406
Fallow	760	0.50	380	0.50	380
Included nonwater service area	1,420	2.54	3,607	1.06	1,505
Gross irrigated agriculture	11,730		28,915		12,008
Gross water service area	18,930		39,735		19,489
II. Nonwater service area					
a. Nonirrigated agriculture	11,240	1.31	14,724	1.06	11,914
b. Native vegetation*	2,620*	1.11	2,908	1.06	2,777
c. Unclassified*	4,210*	1.06*	4,463	1.06	4,463
Gross nonwater service area	18,070		22,095		19,154
III. TOTALS	37,000		61,830		38,643

* Estimated. Bul 71-64 ( ) shows total San Jacinto Subarea to have 54,930 Ac. of native vegetation and 101,580 Ac. of unclassified. The bulk of these areas were compensated for in the tributory run-off discussion. The acreage estimates were based on (4) (6), & (7)

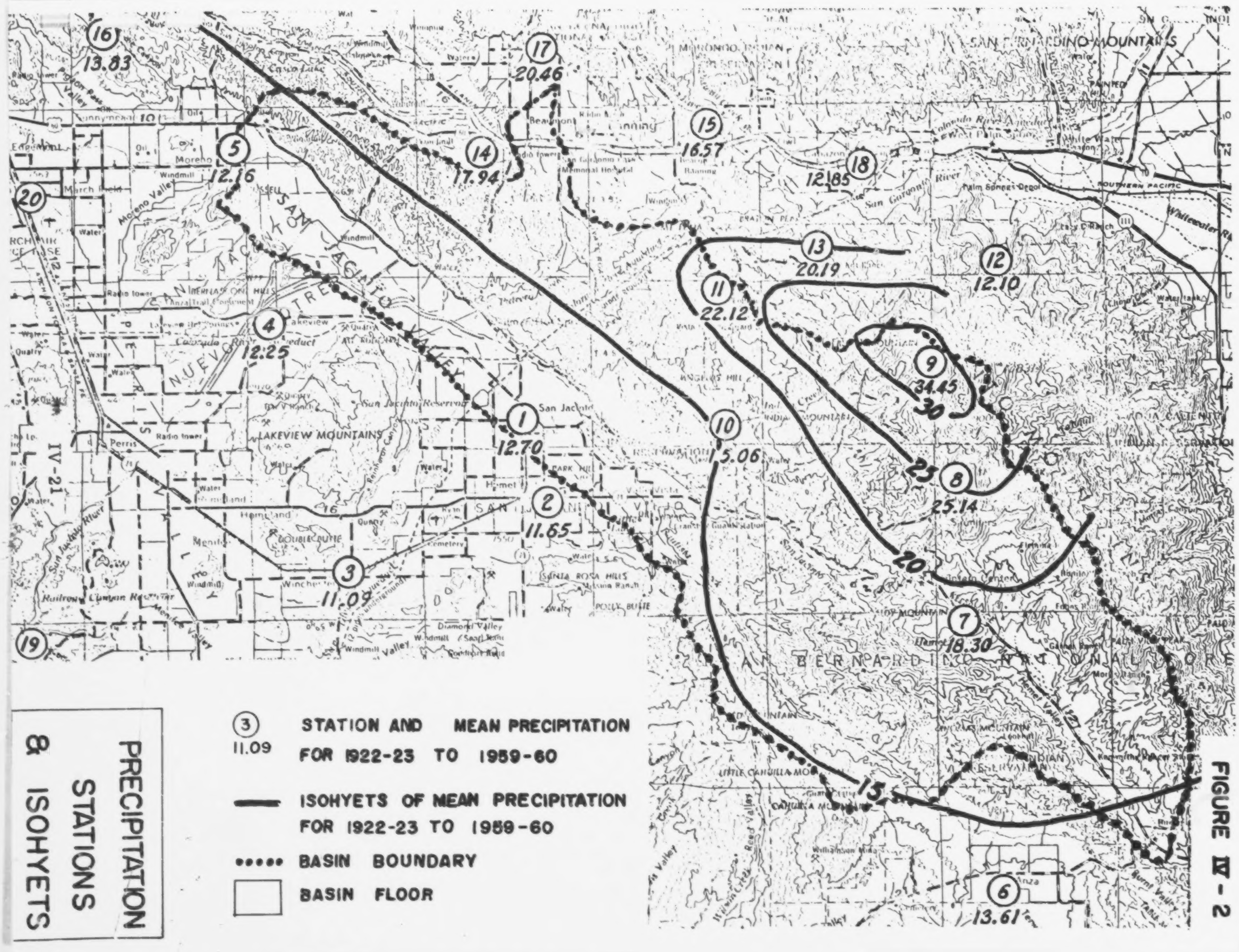
FIGURE IV-1

COLOR ILLUSTRATIONS REPRODUCED
IN BLACK AND WHITE


BASIN BOUNDARY
BASIN FLOOR
BASIN WATERSHED
EXCLUDED AREA
SAN BERNARDINO MOUNTAINS
Banning
SAN GORGONIO PASS
MERIDIAN
SAN JACINTO
BLACK MT
Coahuila Valley
MOUNT
LOS ALAMOS
Dominguez Valley
LOOKOUT MT

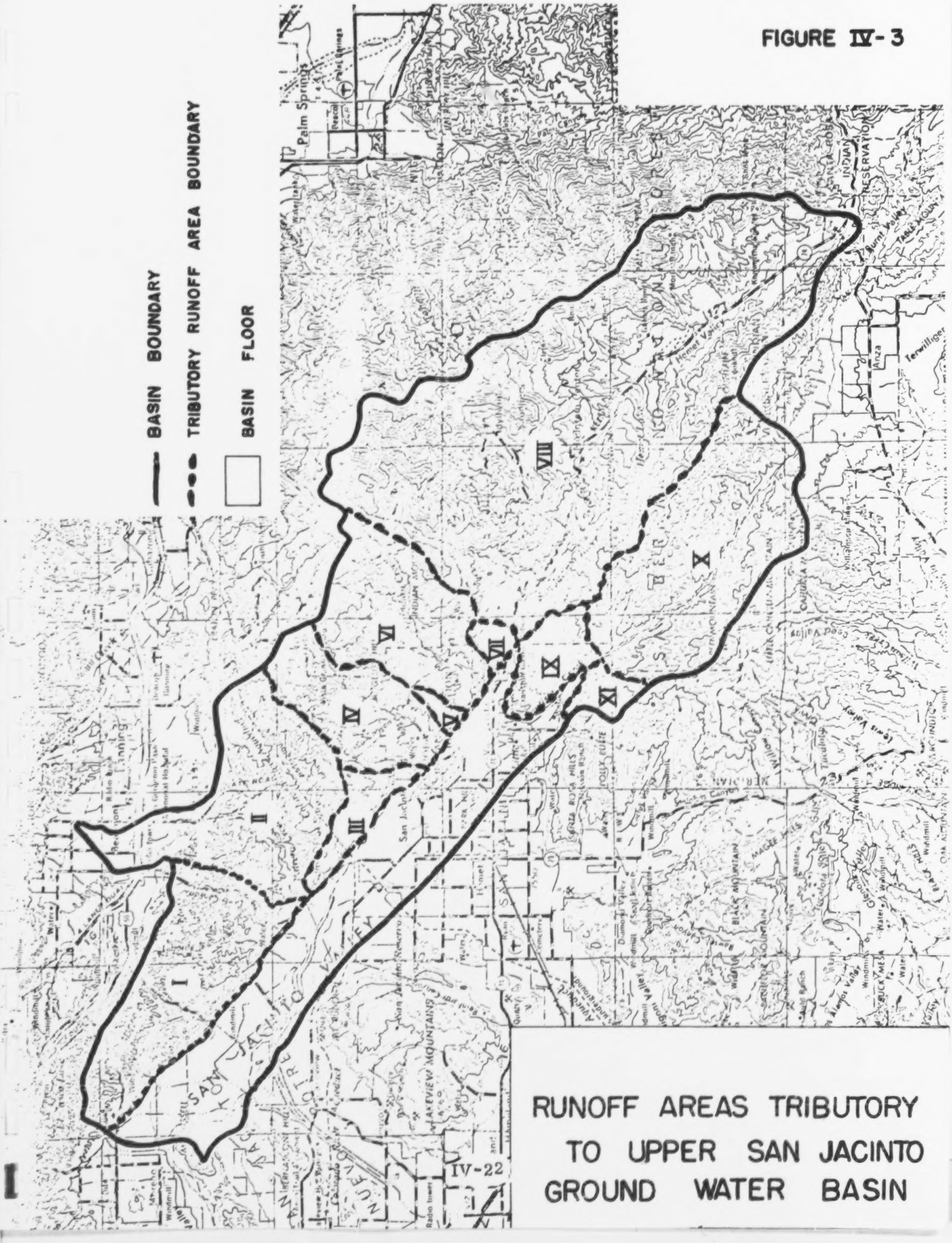
UPPER SAN JACINTO GROUND WATER
BASIN AND WATERSHED

FIGURE IV - 2


16
13.83
17
20.46
15
16.57
18
12.85
SAN BERNARDINO MOUNTAINS
5
12.16
14
17.94
20
13
20.19
12
12.10
11
22.12
4
12.25
9
34.45
30
1
12.70
10
15.06
25
8
25.14
2
11.65
LAKEVIEW MOUNTAINS
SAN JACINTO VALLEY
20
3
11.09
7
18.30
19
15
6
13.61
3
11.09
STATION AND MEAN PRECIPITATION
FOR 1922-23 TO 1959-60
ISOHYETS OF MEAN PRECIPITATION
FOR 1922-23 TO 1959-60
BASIN BOUNDARY
BASIN FLOOR

PRECIPITATION
STATIONS
& ISOHYETS

FIGURE IV-3


BASIN BOUNDARY
TRIBUTARY RUNOFF AREA BOUNDARY
BASIN FLOOR
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
Palm Springs
Banning
Hemet Valley
Anza
Terwilliger
SAN JACINTO VALLEY
LAKEVIEW MOUNTAINS
SANTA ROSA HILLS
San Jacinto
Hemet
Windmill

RUNOFF AREAS TRIBUTARY TO UPPER SAN JACINTO GROUND WATER BASIN

CHAPTER V

WATER QUALITY

This chapter explains the quality of the water spread in the Replenishment Area, quality of water in the shallow ground water mound which formed under the Replenishment Area and the quality of the deep ground water. This chapter also outlines the various procedures used in this study for tracing water quality and the steps taken to prevent misinterpretation of water quality data obtained to determine the extent of mixing and blending of the various waters. Prior to determining the extent of mixing and evaluating the effects on the existing water quality by the water being spread in the Replenishment Area, it should be noted that long term trends or short period fluctuations in the quality of existing ground water might be occurring. These fluctuations or trends could be taking place due to any of the following factors:

1. Greater amounts of water being pumped from deeper levels as the upper water zones are depleted in this multilayered basin.
2. Reversal or modification of ground water slopes and flows due to large ground water extractions.
3. Increased domestic, agricultural and commercial activities throughout the valley and watershed.
4. Interconnection of different aquifers by means of the multitude of wells that have been drilled.

The observed water quality data from wells might also have trends or fluctuations not caused by mixing with the water being spread. Three of the more common reasons for changes in the observed water quality are:

1. Zones in which a well is perforated together with changing of pump capacity.
2. Modifications of a well or its pumping capacity.
3. Lack of backflow devices.

Historical Ground Water Quality (up to 1948)

In 1915 partial chemical analyses of three wells in and near the Replenishment Area were made.(10) The total depth of these wells is unknown but the static water levels are assumed to be near the ground surface since most of the wells in this area were artesian at that time. The chemical quality of water from these three wells is shown below. Also shown is an analysis of Well No. 4S1W 23N2 which is also near the Replenishment Area. (See Figure V-1).

Well No.	Date	CO_3	HCO_3	SO_4	Cl	Total Hardness	TDS
Waring 97	10/1915	0	181	5	11	99	210
Waring 124	10/1915	0	127	5	9	88	160
Waring 122	10/1915	0	217	10	17	147	260
Average of the 3 Waring Wells		0	175	7	12	111	210
4S1W 23N2	10/1965	0	174	6	12	112	206

Recent Water Quality (1948-1965)

During the late 1940s to the present, several agencies began gathering water quality data for the area. However, very little of these data are from wells which are near to the Replenishment Area. Figure V-2 is a plot of chloride concentration versus time in Wells No. 4S1W 26J1 and 4S1W 26J2. This plot shows that the chloride concentration is rather stable over a six-year period.

A lack of sufficient specific data prevents any demonstration of water quality trends over the historical and recent periods. However, the three Waring wells, together with Figure V-2, indicate that the water quality has been rather constant under the Replenishment Area from 1915 to 1965.

Present Water Quality

In conjunction with spreading secondary effluent in the Replenishment Area which started in 1965, a fairly extensive program of water sampling has been carried out. This program includes water samples from:

1. deep wells
2. 3/8-inch diameter pipes which act as piezometers to measure the static water level of the ground water mound that formed
3. sampling pans beneath a spreading basin which capture percolating water

Typical analyses of the water being spread, the well water, water from the piezometers and percolating water from the sampling pans are shown in Table V-1.

The main water quality tracers used in this study are chlorides, sulfates and electrical conductivity. However, at this time only chloride concentration data have been plotted and will be presented herein.

Well Monitoring

Some of the wells monitored in this program are shallow (less than 200 feet deep with static water at 30 feet below the ground surface) while others are quite deep (840 feet deep with static water level 300 feet below the ground surface). It is possible that some of the shallow wells might be chemically degraded through septic tank overflows, agricultural return waters or dairy wastes. Any degradation by one of the above might be misinterpreted as a chemical change in the well water due to the spreading operation. To verify chemical degradation of shallow wells, Figure V-3 was plotted. This figure shows chloride concentration versus well depth for data from years 1965 and 1968. Since the spreading operation began in 1965 it would not be possible for the effluent to have percolated through the soil and entered these wells. However, by 1968 some of the water being spread (effluent) could have reached these wells.

Except for Well No. 4S1W 23L1, as shown on Figure V-1, the chloride concentration does not change appreciably with depth. Thus, it cannot be demonstrated that septic tank, agricultural return waters or dairy wastes have chemically degraded the shallow well water.

A plot of change in chloride concentration of ground water versus distance of a well from the Replenishment Area is shown on Figure V-4. These data are very valuable when used to verify the accuracy of an estimate of the shallow ground water mound size. (See Chapter VIII) It is interesting to note that the wells which show either no change or very little change in chloride concentration are estimated to be either outside the mound perimeter or to have their main source of water below the mound.

On Figure V-5 are plots of chloride concentrations for an eight-year period covering before and during spreading water in the Replenishment Area. These monitored wells are in or near the Replenishment Area and have the longest period of available data. Their depths vary from 296 feet to 830 feet and are located from 20 feet to 4, 900 feet outside the actual Replenishment Area. All of these wells were gravel packed with the exception of 4S1W 25D2. This well, drilled by EMWD using a cable tool drilling rig, is perforated at 170 feet and it is believed that the 170-foot level is below the bottom of the theoretical ground water mound. As a result there is no increase in chloride concentration. As would be expected, Well 4S1W 25N1 at a distance of 4, 900 feet also shows no increase in Cl. The only anomalies appear to be 4S1W 26G1 at 1, 850 feet and 4S1W 23P4 at 2, 200 feet with apparent minimal increases in chloride concentrations. The other three wells (4S1W 25G1 at 3, 100 feet, 26G3 at 2, 400 feet and 23Q3 at 1, 240 feet) show definite increases in chloride concentration. Well No. 4S1W 25G1 started to show effects of receiving spread water in the late spring of 1968 which would agree with the theoretical mound radius of 3, 850 feet in November 1968. Well 4S1W 23Q3 at 1, 240 feet, appears to have received spread water between 1/2 to 1-1/2 years after spreading started, and this would agree closely with its proximity to the Replenishment Area. Well No. 4S1W 23G3 does not have sufficient data to estimate arrival time of the spread water.

It seems probable that the wells which have the poorest chemical quality, the shallow wells close to the Replenishment Area, will be the wells most severely affected by the spread water. This is based on dilution assumptions; i.e., in the larger, deeper wells, the higher chemical content spread water should represent a small amount of the total water entering the well. In the shallow wells the spread water will eventually represent the major amount of water entering the well.

Piezometer Monitoring

Unfortunately, the piezometer network was not installed prior to the start of spreading operations to establish background on the ground water. As a result, there is no data available to establish the presence or quality of water in the zones presently occupied by the mound.

Chemical analyses of water from the first piezometers indicated that the shallow ground water was definitely the same as the water being spread. However, several piezometers had water with very high total dissolved solids (TDS) but in a short period the high TDS water disappeared. When it was apparent that the shallow mound was expanding, additional piezometers were installed over a larger area. Water quality from a typical piezometer is shown in Table V-1.

Sampling Pans

A typical analysis of water from a sampling pan is shown in Table V-1. Discussion of these pans and the water quality is contained in Chapter VIII.

Table V-1

TYPICAL WATER QUALITY OF WELL, PIEZOMETER, SAMPLING PAN AND RECHARGE WATERS

(milligrams per liter)

	1965-68 Ave. Quality of Water Spread	Well No. 4S1W 25D2 @ 235' 11/1/68	Piezometer C-3 5/67	Sampling Pan 6F 5/67 - 6/68 Average
Calcium	75	44	76	-
Magnesium	12	2	20	-
Sodium	125	23	124	-
Potassium	19	3	4	-
Ammonium	15	trace	0.1	-
Carbonate	0	0	0	-
Bicarbonate	259	136	220	-
Sulfate	131	4	140	-
Chloride	114	19	133	-
Nitrate	24	5	40	12.4
Fluoride	0.8	0.27	0.8	-
Total Dissolved Solids	674	262	700	-
Boron	0.7	0.00	0.6	-
Methylene Blue Alkyl Surfactants	1.4	0.00	0.3	0.51
pH	7.6	7.95	7.6	-
E.C. x 10^6	1053	405	1100	-
Hardness as $CaCO_3$	208	118	276	-
Chemical Oxygen Demand (Dissolved)	20	-	18	13.9
Suspended Solids	-	-	0	2.0
% Volatile Suspended Solids	-	-	-	62.8

FIGURE V-1

WELL LOCATION MAP
TOWNSHIP 4 SOUTH
RANGE 1 WEST
SCALE 1" = 2000'

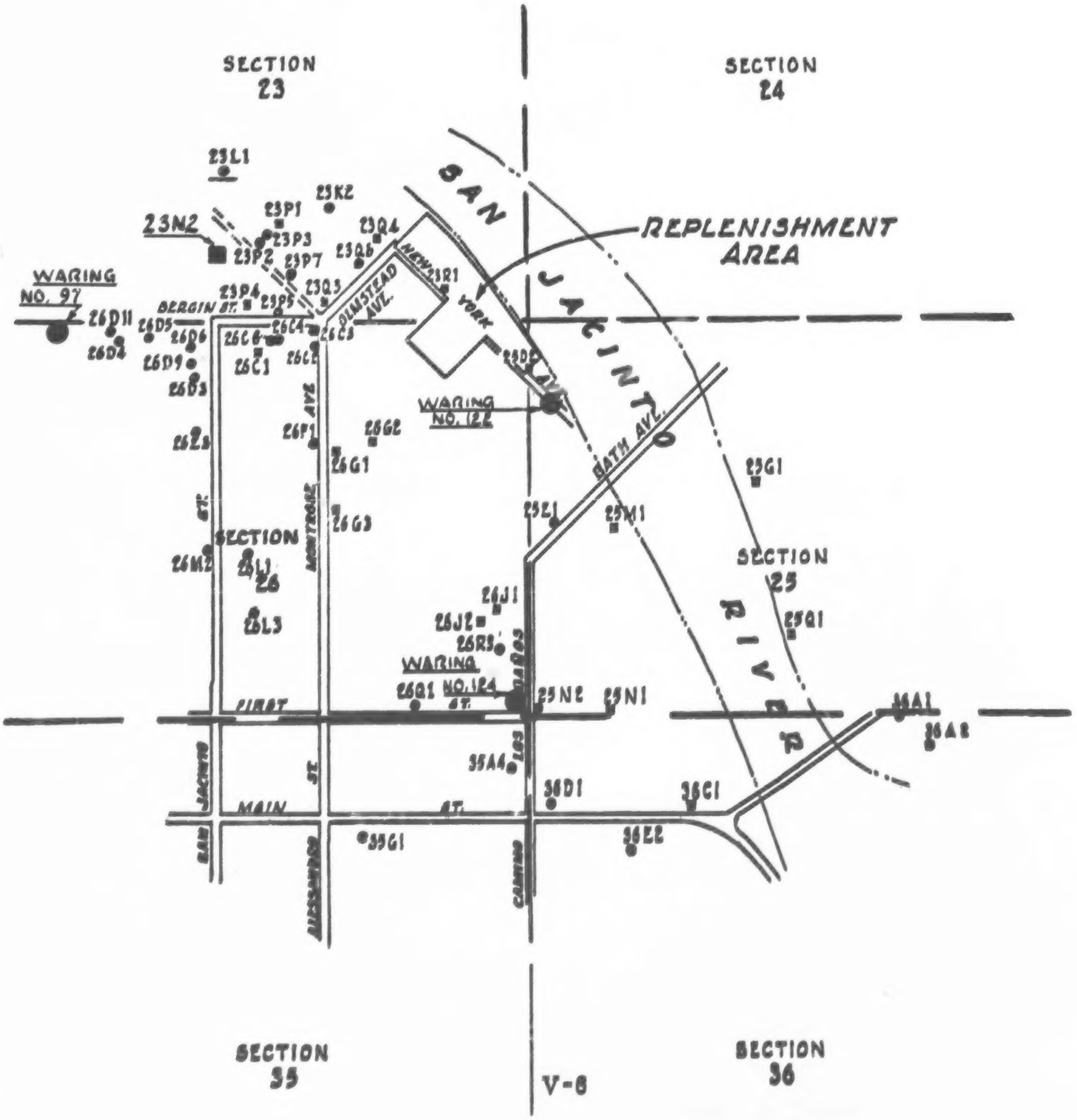
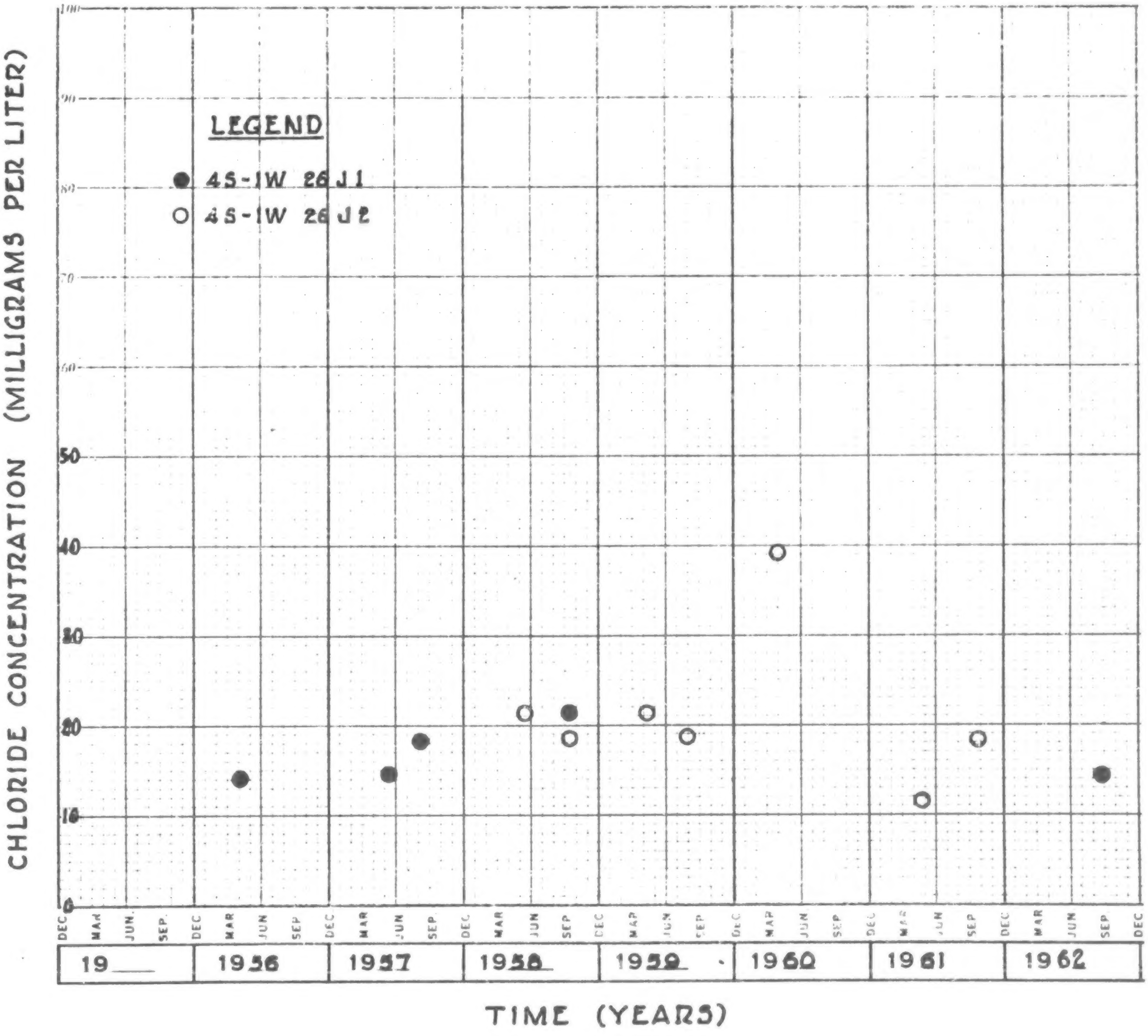

N
SECTION 23
SECTION 24
SECTION 25
SECTION 26
SECTION 35
SECTION 36
SAN JACINTO RIVER
REPLENISHMENT AREA
WARING NO. 97
WARING NO. 122
WARING NO. 124
23L1
23K2
23P1
23N2
23P3
23P2
23P7
23Q4
23Q6
23R1
23P4
23P5
23Q3
26D11
26D5
26D6
26D4
26D9
26D3
26C6
26C4
26C3
26C2
26C1
26E3
26F1
26G2
26G1
26G3
26M2
26L1
26L3
26J1
26J2
26R3
26Q1
26R2
25D
25E1
25M1
25G1
25Q1
25N2
25N1
36A1
36A2
35A4
36D1
36C1
36E2
35G1
BERGIN ST.
OLMSTEAD AVE.
NEW YORK AVE.
BATH AVE.
MONTROSE AVE.
FIRST ST.
MAIN ST.
SAN JACINTO ST.
ALESSANDRO ST.
CAMINO

FIGURE V-2

CHLORIDE CONCENTRATION IN WELLS
4S-1W 26J1 AND 4S-1W 26J2
VERSUS
TIME



CHLORIDE CONCENTRATION IN WELL WATER
VERSUS
DRILLED DEPTH OF WELL

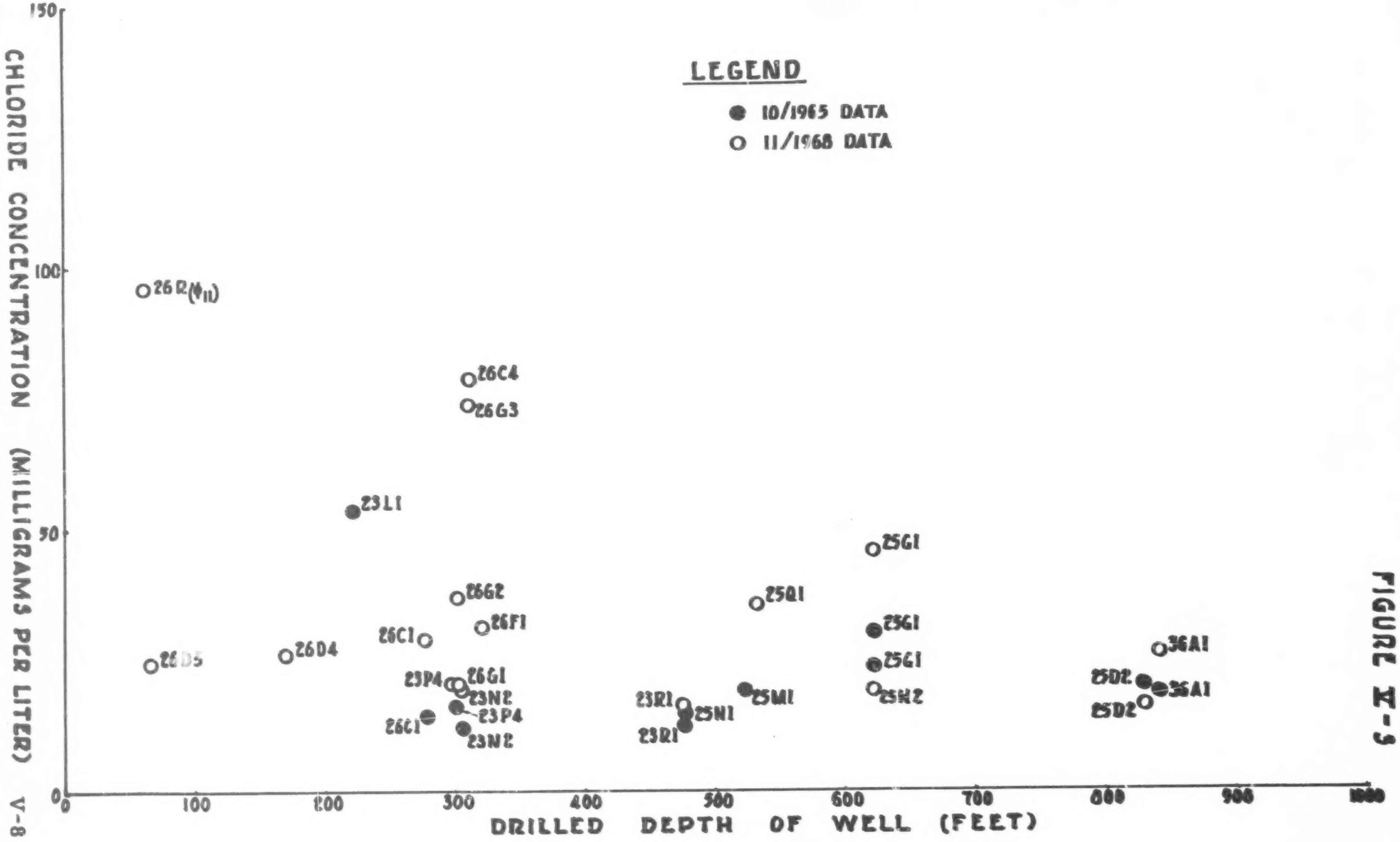
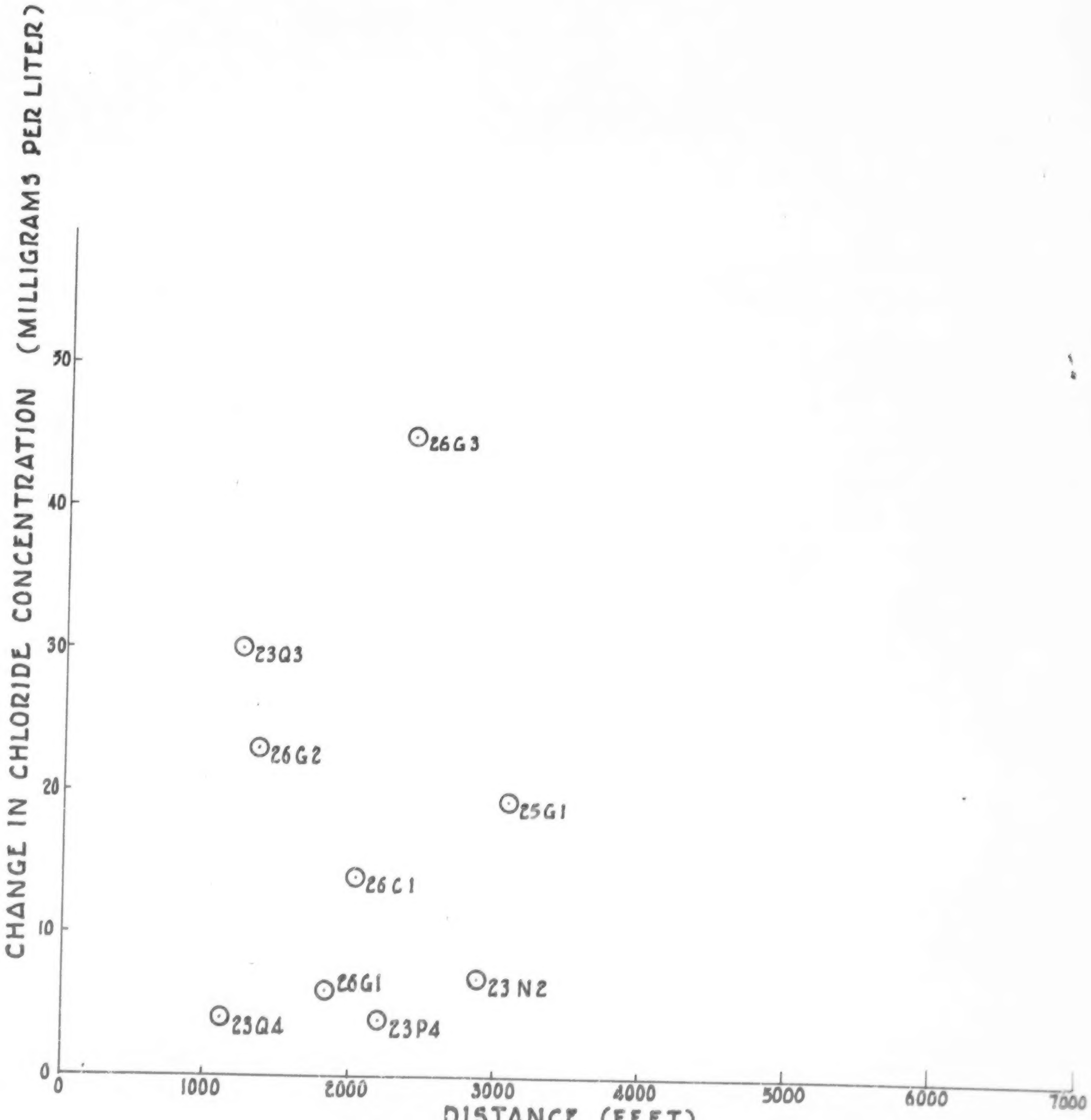


FIGURE V-3

FIGURE V-4

CHANGE IN CHLORIDE CONCENTRATION
VERSUS
DISTANCE OF WELL FROM REPLENISHMENT AREA



CLEARPRINT PAPER CO. NO. C336 TEN YEARS BY MONTHS X 100 DIVISIONS.
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CHLORIDE CONCENTRATION IN WELL WATER
VERSUS
TIME

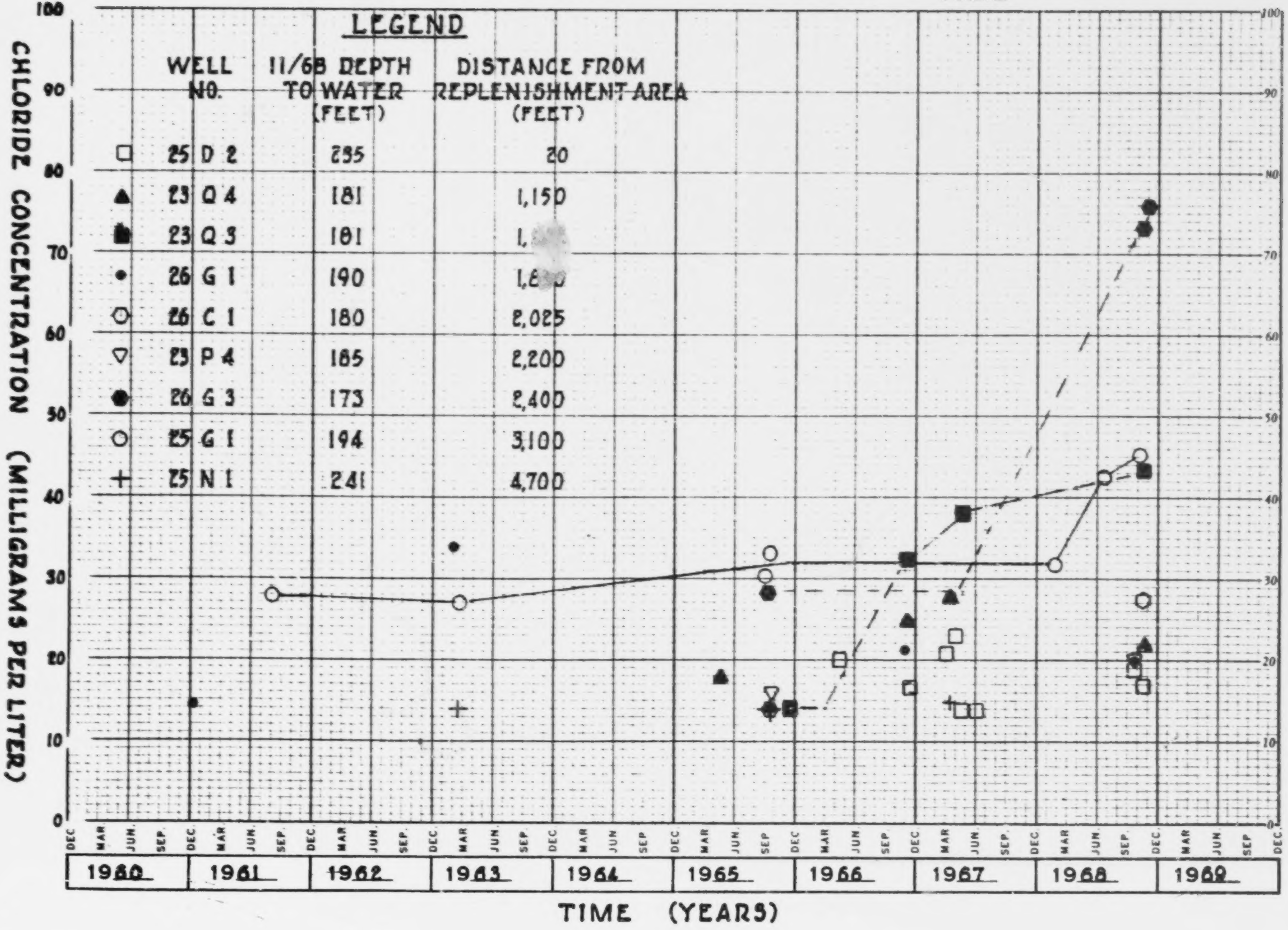

FIGURE V-5

CHAPTER VI

SPREADING BASIN INVESTIGATIONS

Selection of a site for ground water recharge which had sandy soils, or sand and gravel soils would have been very desirable as it would have permitted high infiltration rates. The most suitable locations are over seven miles from the Hemet-San Jacinto Valley Water Reclamation Facility and a seven-mile force main could not be economically justified with the daily flow at that time. Further downstream and closer to the treatment facility are several other suitable locations, but these are either privately owned or directly over a domestic water well system. The privately owned properties were not available at a reasonable cost. In view of the above, the best site available was purchased by the District and is shown on Figure VI-1.

This site, termed the "Replenishment Area", is approximately 40 acres in area and is northeasterly of the City of San Jacinto. The Replenishment Area is geographically located in the Pressure Area which was described in Chapter II, hence ground water had been artesian. However, ground water levels have dropped 170 feet in the past 20 years.

The spreading basins were constructed in the Replenishment Area as shown in Figure VI-1 and they have been numbered by construction sequence. Basins 1 through 4 were constructed in February 1965, while 5 and 6 were finished in May of that year. Basins 7 through 10 were constructed in late 1965 at a time when the existing basins had low infiltration rates and it appeared that the then-existing basins were not adequate to percolate the entire daily flow. The water to be percolated is secondary effluent from the Hemet-San Jacinto Valley Water Reclamation Facility. It is pumped through a 14-inch force main, down the center of New York Avenue with eight-inch feeders to Basins 1 through 6 and ten-inch feeders to Basins 7 through 10. Each basin has a separate water meter except Basins 5 and 6 which are alternately filled through the same meter. These meters are calibrated by EMWD and are accurate within 1%. There have been times when a single water meter for Basins 5 and 6 has been undesirable and this, as well as several other problems mentioned below have forced the consideration of these two basins as one. All calculations, graphs and tables consider Basins 5 and 6 to be one basin.

Prior to the completion of the Hemet-San Jacinto Valley Water Reclamation Facility, the Board of Directors of Eastern Municipal Water District approved the purchase of Colorado River water to begin the spreading and replenishment operation. Spreading began in Basins 1 through 4 on March 12, 1965, and in Basins 5 and 6 in May 25, 1965. On June 28, 1965, recharging with Colorado River water was stopped, with 567 acre feet having been spread in the first six basins. All six basins were allowed to dry until July 20, 1965, when the spreading of approximately 3 acre feet per day of effluent from the Reclamation Facility began.

Method of Spreading

The method of spreading effluent from the Hemet-San Jacinto Valley Water Reclamation Facility is intermittent flooding of the basins so that they are alternately wet and dry. Use of an intermittent spreading cycle has two primary objectives:

1. To obtain the highest possible hydraulic load, expressed as acre feet per acre per day, or feet per day, in order that the land required for spreading is minimized;
2. To achieve optimum degree of tertiary treatment so that the percolated water will be suitable for subsequent beneficial uses.

Both of these objectives are related to the quality of wastewater and to the nature of the soil system. However, for any given wastewater quality and soil system, both objectives are a function of the method of spreading.(10)

The intermittent spreading cycle has been varied during this study. A three-day cycle has been the most successful in sustaining high infiltration rates. Thus, a basin is filled or wetted for one day and it dries for two days. During the dry period the basin is free from ponded water. The amount of water pumped into a basin in order that it is wet for only 24 hours is determined by the infiltration rate for that basin during its last cycle multiplied by the basin area. Since a given volume of water is spread every day, slight variations in any set intermittent cycle are necessary, but these variations are minimized by careful sequencing and use of multiple basins.

During the early stages of spreading Colorado River water, the four basins were not free of ponded water before they were refilled. Effectively, the spreading operation was one of constantly flooded basins rather than intermittent spreading. In May 1965, the spreading method was changed so that a three-day intermittent spreading cycle was attained in Basins 1 through 4. On the same day, Basins 5 and 6 were put into operation and constantly flooded similar to the operation previously used in the original four basins. It was thought that this would lead to contrasting data between flooded and intermittently spread basins. But this was not possible as Colorado River water was spread for only four more days, until June 27, 1965. The basins were allowed to dry until July 20, at which time the Hemet-San Jacinto Valley Water Reclamation Facility became operable and the effluent therefrom was pumped to the spreading basins.

The effluent was spread in each basin using the same cycle as was previously used. Thus, Basins 1 through 4 were intermittently spread while Basins 5 and 6 were continued as constantly flooded basins. If 5 and 6 had been used intermittently at that time it was doubtful if sufficient water would have infiltrated the soil. With completion of the four additional basins in January 1966, all of the basins were put on an intermittent cycle. The four new basins increased the total spreading basins in the Replenishment Area to 10 and the total spreading area to 15.9 acres. To June 30, 1968, 3,836 acre feet of water has been spread, of which 567 acre feet is Colorado River water and 3,269 acre feet is effluent.

Infiltration Rates

A breakdown by basins of the total amount of water spread is shown in Tables VI-1 through VI-6. Each table shows the amount of water applied to a basin monthly, as well as the computed monthly average infiltration and hydraulic load rates. While both rates have the same units of measurement, feet per day, they are different measurements. The monthly infiltration rate is the arithmetic average of the daily infiltration rates which are calculated only when a basin has water in it. The formula shown below is used to calculate infiltration rates:

$$\frac{IR = Vm \pm (\ h)\ (A)\ - Ve + Vp}{(A)\ (T)} \times \frac{24 \text{ hrs.}}{\text{day}}$$

when IR = Infiltration Rate (acre feet per acre per day, or feet per day)
Vm = Volume of water through meter during time T (acre feet)
h = Change in water surface elevation during time T (feet)
A = Area of particular spreading basin (acres)
Ve = Volume of water evaporated (acre feet)
Vp = Volume of precipitation (acre feet)
T = Time (hours, maximum T = 24 hours.)

Thus the infiltration rate obtained by the above calculation measures the velocity with which water passes the soil-water interface. Graphs of the infiltration and hydraulic load rates are shown on Figures VI-2 through Figure VI-7.

Each spreading basin has exhibited a slight rise in infiltration rates during the summer and a slight decrease during the winter. These rate changes can probably be attributed to the change in water viscosity due to water temperature changes. Fluctuations of short duration in the infiltration rates are mainly caused by either a heavy load of suspended solids and/or algae in the water. During the first few months after the Hemet-San Jacinto Valley Water Reclamation Facility started operations the heavy load of suspended solids in the effluent sealed the basin soil, thereby necessitating scarifying of the soil. The rippers used to scarify are approximately 12 inches long and are approximately 9 inches on center. After scarifying, the basins showed an increase in infiltration rates.

During November and December, 1965, and January 1966, all spreading basins exhibited a decrease in infiltration rates, using a spreading cycle of one day wet, two days dry. The basin soil wasn't drying within two days and a slime layer, apparently algae, on the wet basin soil was inhibiting infiltration rates. A four-day cycle, one wet - three dry, allowed sufficient drying to minimize the effect of the algae, but thorough drying was not the complete solution as the basins were continuing to receive algae from the storage ponds at the Hemet-San Jacinto Valley Water Reclamation Facility. These storage ponds at the Reclamation Facility were intended to be used as large "wet wells" from which a constant flow of various magnitudes could be pumped to the spreading basins rather than pumping the fluctuating flows which are typical of a treatment plant. A different pumping method was worked out which took the effluent directly from the treatment plant to the spreading basins, bypassing the storage ponds. This method was made operational in June 1966 and eliminated the heavy algae loading and the need for the four-day cycle.

The infiltration rates started increasing in March 1966, when the four-day cycle was in use and continued to increase through July 1966, with the new pumping method and a three-day cycle. The four-day cycle was dropped during the summer of 1966 as it was not necessary, and it was used only sparingly during the following winter. During the spring and summer of 1967 the cycle was again modified as all of the basins demonstrated a rise in infiltration and hydraulic load rates and it was not possible to match perfectly a three-day cycle to both the quantity of flow and the number of basins. Thus, the number of basins in use was reduced and the cycle was as follows: Basins 1, 2 and 4 wet one day, dry three days; Basins 5 and 6 wet two days, dry two days. Thus, Basin 1 received all of the flow for one day, Basins 2 and 4 received all the flow the next day, 5 and 6 for the next two days, and the cycle repeated. Basins 7 and 8 were not used during these months as they were not needed. As can be seen from Figures VI-2 through VI-7, this method obtained high continued rates during 1967, but each basin exhibited a typical indicated decrease in rates during the winter of 1967-68. During the 1967-68 winter, Basin No. 7 was used and this permitted a continuation of a three-day cycle for each basin.

Since their construction in 1965, Basins 8, 9 and 10 have not been continuously used. These three basins have been used only for storage during periods of heavy rainfall and subsequent runoff. However, since need for storage has been intermittent, infiltration and hydraulic load data are also intermittent. Thus, these scattered data have been omitted from both the tables and graphs.

It is apparent that the infiltration rate is affected by many factors, of which few can be easily and economically controlled. Once the site for spreading is selected, one of the most important controllable factors is the intermittent cycle in use. A second controllable factor is the amount of suspended solids in the effluent. A good activated sludge effluent will usually have less than 15 milligrams per liter suspended solids. However, if the effluent is stored or if a basin is not allowed to dry, algae will bloom and can cause a suspended solids increase of more than 10 times normal. The single fact that the infiltration rate is high doesn't necessarily indicate that a large volume of water is infiltrating the soil. The purpose in determining the infiltration rate relates to the need to infiltrate as much water as possible in the smallest area possible. A better parameter than infiltration rate for measuring the overall efficienty of land area - water volume relationship over a period of time is the hydraulic load rate.

Hydraulic Load Rates

The average hydraulic load rate, as defined in the Report of Research on Wastewater Reclamation at Whittier Narrows equals the total volume of water applied during the month divided by the number of days in the month divided by the surface area of the basin.(10) Thus, hydraulic load can be used to show the amount of water infiltrating the ground during any period of time regardless of the wet-dry spreading cycle used. Hydraulic load rate is a meaningful parameter and can be used to directly compare soils or spreading basins which are being used with different spreading cycles. Hydraulic load by its definition is equal to the infiltration rate only when a basin is constantly wet. Tables VI-1 through VI-6 show the hydraulic load for each spreading, together with the infiltration rates and various unusual factors which had a bearing on either the hydraulic load or the infiltration rate. Figures VI-2 through VI-7 are graphs of the hydraulic load rate for each basin.

The hydraulic load rates have been very low for Basins 2, 3 and 4. During 1965 and 1966 all the basins had low rates, but they increased during 1967 and the first six months of 1968. However, there has been very little increase in 1968 over 1967.

Maintenance

The vegetative growth in several of the spreading basins has been quite severe. Basins 1 through 4 undergo complete regrowth within two months after the original growth has been disced or burned. However, Roto-tilling the soil to a 14-inch depth prevents regrowth for a period of four months. Basins 5, 6, 7 and 8 have not experienced as severe a growth problem as the original four, as they have a more sandy soil and are flooded to a deeper depth. Apparently the more important of the two factors is the flooding depth. Growth around the sides or dikes of a basin can be rather easily controlled from the top of a dike. Thus, the main problem is control of growth occurring in the bottom of a rather shallow spreading basin.

Each of the basins have sealed at one time or another, even though they are intermittently wetted and dried. Discing, roto-tilling and scarifying have been used to break up the top few inches of soil. Each method has its own depth to which it normally breaks up or turns over the soil: Discing, to 6 inches; Roto-tilling to 14 inches; scarifying to 12 inches. In 1968 gravel ranging in size from 3/4-inch to pea gravel was spread 6 inches deep in Basin No. 3. It has prevented the recurring weed problem, but the basin has not greatly increased in either infiltration or hydraulic load rates. The cost for this operation far exceeded any immediate benefit of higher infiltration and will probably exceed the cost of weed maintenance for over 15 years.

For the purposes of unclogging the basin soil and eliminating severe vegetative growth, each basin has been scarified, disced or Roto-tilled at regular intervals; Basins 1, 2 and 4 approximately four times per year, and Basins 5, 6, 7 and 8 about twice yearly.

There has been only one area where water pumped into a basin would flow under a dike and appear on the surface of an adjoining basin. This occurred in January 1967 in Basins 5 and 6. This problem is solved only by flooding both basins at the same time. Thus, these two basins have been considered as one since that time.

TABLE VI-1
MONTHLY HYDRAULIC LOAD AND INFILTRATION RATES FOR BASIN NO. 1

Date	Vol. of Water Applied Acre Feet	Ave. Hydraulic Load feet/day	Ave. Infiltration Rate feet/day
Colorado River Water			
March 1965	45.107	2.37[a]	2.37
April	44.852	1.49	1.63
May	45.824	1.48	1.68
June	41.288	1.45	1.64
Reclaimed Water			
July 1965	5.764	.55[b]	1.08
August	14.983	.51	0.59
September	2.900	.10	0.16[c]
October	2.676	.14[d]	0.56
November	-		-
December	-		-
January 1966	-		-
February	2.778	.16[e]	0.58
March	6.292	.21	0.80[f]
April	7.245	.25	1.07
May	6.391	.22	0.94
June	6.906	.24	1.03
July	1.948	.21[g]	1.03
August	7.979	.27	1.03
September	7.890	.28	1.95
October	5.679	.19	.74
November	4.414	.15	.66
December	-[h]	-[h]	-[h]
January 1967			
February			
March			
April	2.254	.08	.47
May	6.591	.22	.83
June	10.188	.36	1.54[i]
July	10.054	.34	1.56
August	20.646	.70	1.80
September	16.356	.57	1.92
October	23.957	.82	2.00
November	13.389	.47	1.44
December	11.509	.39	1.24

Area = 0.95 Acres

a Began spreading March 12, 20 days in month
b Began spreading July 21, 11 days in month
c Basin Scarified 9.28
d Stopped spreading in basin, 20 days in month
e Began spreading February 11, 18 days in month
f Basin scarified March 4
g 10 days in month
h Basin drying December through March to install sampler
i Basin Scarified 6/9/67

Table VI-1 Continued

Date	Vol. of Water Applied Acre Feet	Ave. Hydraulic Load feet/day	Ave. Infiltration Rate feet/day
Reclaimed Water			
January 1968	3.995	.14	1.26
February	8.556	.31	1.89
March	6.167	.22	1.46
April	16.456	.58	1.91
May	4.361[j]	.47[j]	2.26[j]
June	14.720	.52	2.10
July	12.862	.44	2.14
August	13.335	.45	1.91
September	12.839	.44	1.83
October	13.290	.45	1.61
November	11.986	.44	1.50
December	12.456	.41	1.31
Total to Date	506.883	19.09	53.52
Average		0.49	1.37

[j] 10 days in month

TABLE V1-2
MONTHLY HYDRAULIC LOAD AND INFILTRATION RATES FOR BASIN NO. 2

Date	Vol. of Water Applied Acre Feet	Ave. Hydraulic Load feet/day	Ave. Infiltration Rate feet/day
Colorado River Water			
March 1965	17.784	.90[a]	1.38
April	15.096	.46	.46
May	8.699	.26	.40
June	5.406	.18[b]	.48
Reclaimed Water			
July 1965	2.502	.19[c]	.47
August	6.714	.20	.60
September	4.908	.16	.38[d]
October	5.434	.18	.53
November	5.750	.17	.50
December	7.703	.23	.43
January 1966	3.362	.10	.30
February	3.366	.11	.36[e]
March	3.554	.10	.38[f]
April	4.191	.13	.49
May	4.464	.13	.56
June	4.062	.12	.54
July	2.131	.18[g]	.86
August	7.790	.23	.74
September	5.715	.17	.57
October	4.911	.14	.52
November	3.630	.11	.49
December	-[h]	-[h]	-[h]
January 1967			
February			
March			
April	.962[i]	.08[i]	.28[i]
May	6.787	.20	.59
June	2.816	.09	.62
July	1.660	.17[j]	.65
August	9.932	.29	.82
September	7.607	.23	.81

Area = 1.10 acre

a Began spreading March 14, 18 days in month
b 27 days in month
c Began spreading July 20, 12 days in month
d Scarified 9/13
e Basin Scarified February 23
f Began spreading every 4th day March 2
g 11 days in month
h Basin drying December through March to install sampler
i 11 days in month
j 9 days in month

Table V1-2 Continued

Date	Vol. of Water Applied Acre feet	Ave. Hydraulic Load feet/day	Ave. Infiltration Rate feet/day
Reclaimed Water			
October 1967	1.081	.20[k]	.49
November	-		-
December	4.542	.13	1.05
January 1968	5.913	.17	.52
February	4.973	.16	.55
March	-[1]	-[1]	-[1]
April	-	-	-
May	5.749	.17	.65
June	4.290	.13	.58
July	10.681	.31	.80
August	11.244	.36	.73
September	8.568	.26	.57
October	9.583	.28	.56
November	7.839	.24	.48
December	6.138	.18	.38
Total to Date	237.537	8.10	22.57
Average		0.21	0.58

k 5 days in month
1 Basin drying for Dike Repair & Weed Control

TABLE VI-3
MONTHLY HYDRAULIC LOAD AND INFILTRATION RATES
FOR
BASIN NO. 3

Date	Vol. of Water Applied Acre Feet	Ave. Hydraulic Load feet/day	Ave. Infiltration Rate feet/day
Colorado River Water			
March 1965	21.482	.98[a]	.91
April	17.439	.51	.53
May	10.944	.31	.49
June	9.088	.26	.59
Reclaimed Water			
July 1965	2.505	.18[b]	.40[c]
August	2.556	.07	.38
September	4.967	.14	.40
October	6.680	.19	.50
November	5.623	.16	.38
December	8.138	.26	.32
January 1966	3.081	.09	.26
February	6.028	.19	.29[d]
March	3.043	.09	.29[e]
April	3.829	.11	.42
May	4.566	.13	.47
June	5.144	.17	.50
July	2.200	.17[f]	.61
August	6.135	.17	.51
September	6.003	.17	.39
October	4.199	.12	.40
November	4.386	.13	.38
December	1.789	.14[g]	.24
January 1967	3.230	.09	.21
February	2.139	.07	.27
March	2.422	.07	.32
April	.928	.03	.28
May	2.471	.07	.52
June			
July			
August			
September	3.645	.11	1.14
October	1.662	.24[h]	.73
November			
December	2.605	.07	.57

Area = 1.15 acre

a Began spreading March 13, 19 days in month
b Began spreading July 20, 12 days in month
c Basin scarified September 15
d Basin scarified February 23
e Began spreading every 4th day March 6
f 11 days in month
g 11 days in month
h 6 days in month

Table V1-3 Continued

Date	Vol. of Water Applied Acre Feet	Ave. Hydraulic Load feet/day	Ave. Infiltration Rate feet/day
Reclaimed Water			
January 1968	4.535	.13	.43
February	5.547	.17	.65
March	- [i]	- [i]	- [i]
April	3.212	.35[j]	.56[j]
May	- [k]	- [k]	- [k]
June	-	-	-
July	2.856	.08	.35
August	3.766	.11	.42
September	3.634	.11	.39
October	3.594	.10	.35
November	3.459	.10	.30
December	2.856	.08	.22
Total to Date	205.929	6.72	17.37
Average		0.17	0.45

i Basin dry for Dike repair
j 8 days in month
k Basin dry in May and June to apply rock

TABLE V1-4
MONTHLY HYDRAULIC LOAD AND INFILTRATION RATES FOR BASIN NO. 4

Date	Vol. of Water Applied Acre Feet	Ave. Hydraulic Load feet/day	Ave. Infiltration Rate feet/day
Colorado River Water			
March 1965	25.639	.99[a]	1.15
April	27.679	.71	.75
May	16.728	.42	.63
June	8.729	.22	.62
Reclaimed Water			
July 1965	3.892	.25[b]	.37
August	3.905	.10	.26
September	5.306	.14	.18[c]
October	6.910	.17	.38
November	5.725	.15	.40
December	5.449	.14	.19
January 1966	3.698	.09	.25
February	2.472	.10	.24[d]
March	3.779	.09	.28[e]
April	4.225	.14	.34
May	5.847	.15	.40
June	5.113	.13	.50
July	1.899	.12[f]	.73
August	6.643	.17	.47
September	6.558	.17	.33
October	4.987	.12	.42
November	3.908	.10	.29
December	1.636	.21[g]	.61
January 1967	3.212	.08	.16
February	2.208	.06	.18
March	2.645	.07	.29
April	1.274	.04	.37
May	5.203	.13	.36
June	2.502	.06	.72
July	2.069	.05	.59
August	13.110	.33	.82
September	11.137	.29	.68
October	4.337[h]	.17[h]	.76[h]
November			
December	4.154	.10	.35

Area = 1.29 acre

a Began spreading March 12, 20 days in month
b Began spreading July 20, 12 days in month
c Basin scarified September 28
d Basin scarified February 23
e Began spreading every 4th day
f 12 days in month
g 6 days in month
h 20 days in month

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Table V1-4 Continued

Date	Vol. of Water Applied Acre Feet	Ave. Hydraulic Load feet/day	Ave. Infiltration Rate feet/day
Reclaimed Water			
January 1968	2.299	.06	.31
February	6.125	.16	.64
March	1.869	.05	.25
April	3.061	.08	.25
May	2.690	.09	.44
June	3.870	.10	.49
July	7.016	.17	.42
August	7.856	.20	.47
September	7.581	.20	.49
October	7.321	.18	.41
November	6.483	.17	.39
December	6.349	.16	.28
Total to Date	275.098	7.88	19.91
Average		9.18	0.44

TABLE V1-5
MONTHLY HYDRAULIC LOAD AND INFILTRATION RATES FOR BASIN NO. 5 & 6

Date	Vol. of Water Applied Acre Feet	Ave. Hydraulic Load feet/day	Ave. Infiltration Rate feet/day
Colorado River Water			
March 1965			
April			
May	60.347	.91[a]	1.23
June	32.365	.50	1.48
Reclaimed Water			
July 1965	18.099	.62[c]	3.27
August	46.757	.75	1.15
September	57.889	.90	1.04[d]
October	52.625	1.51	1.60
November	63.336	.97	1.21
December	55.032	.83	1.03
January 1966	14.518	.24[e]	.43
February	3.468	.30[f]	.56
March	34.412	.57	2.68[gh]
April	36.240	.63	2.67
May	31.153	.53	2.38
June	40.576	.70	2.34
July	20.628	.92[i]	2.22
August	42.397	.71	2.32
September	31.767	.82	2.31
October	51.002	.86	2.25
November	42.695	.73	2.08
December	-		
January 1967	-		
February	12.637	1.05[jk]	2.50
March	25.200	.42[l]	1.67
April	34.080	.59	1.06
May	32.087	.54	1.02
June	67.908	1.17	1.62
July	35.334	.59	2.35
August	48.630	.82	1.81
September	58.216		

Area = 1.93 acre

a Basin area 2.14
b 10 days in month
c Began spreading July 27, 5 days in month
d Basin scarified September 14
e Basin area 1.93
f 12 days in month
g Began spreading every 4th day
h Basin scarified March 4
i 12 days in month
j Basin area .95
k 13 days in month
l Basin area 1.93

Table V1-5 Continued

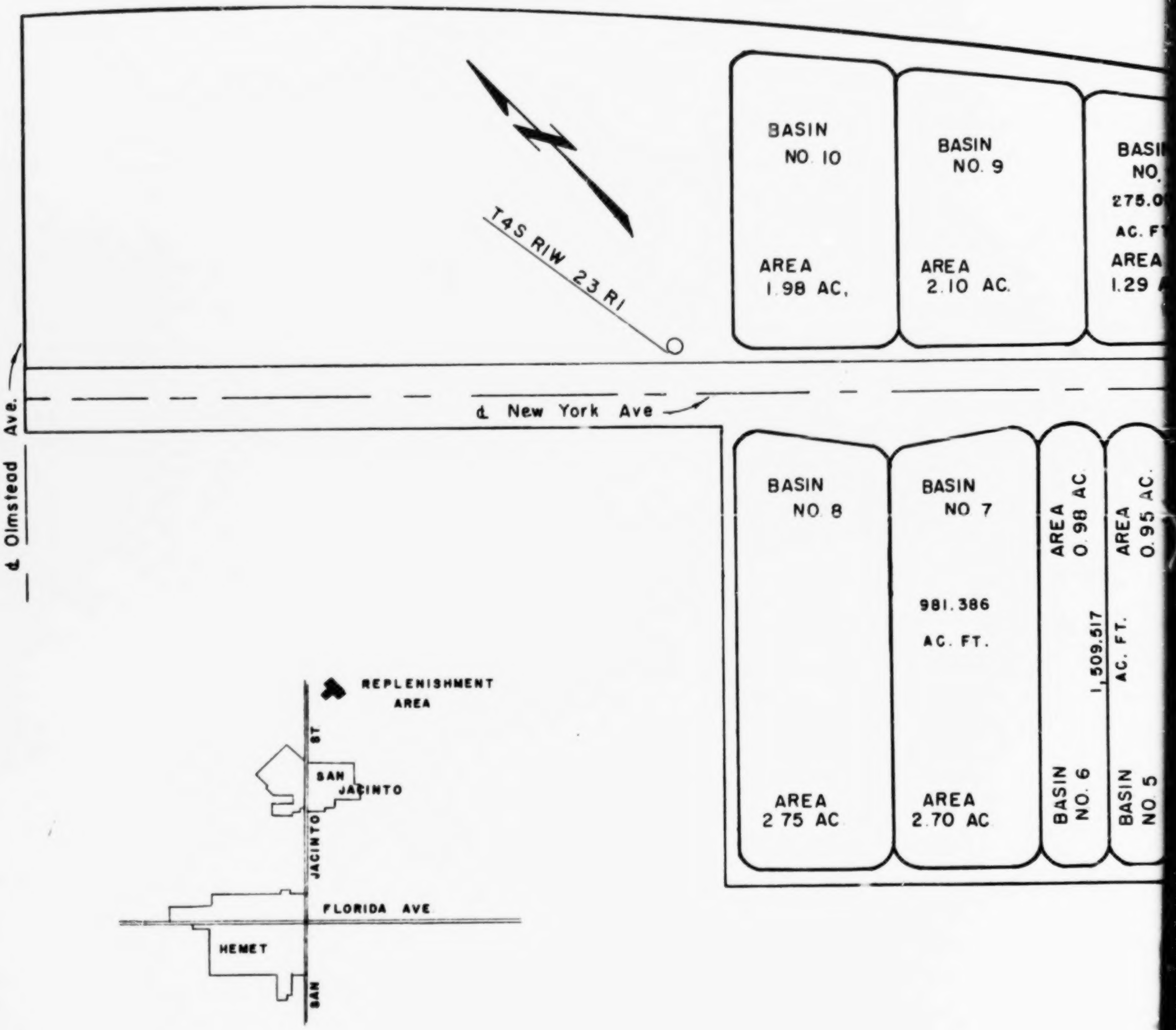
Date	Vol. of Water Applied Acre Feet	Ave. Hydraulic Load feet/day	Ave. Infiltration Rate feet/day
Reclaimed Water			
October 1967	40.494	1.10	1.41
November	18.636	.32	1.34
December	29.517	.49	1.14
January 1968	18.412	.31	1.29
February	24.892	.44	1.28
March	42.022	.73	1.18
April	29.018	.50	1.03
May	32.879	.53	1.17
June	30.888	.53	1.22
July	29.336	.48	1.06
August	31.746	.52	1.14
September	39.637	.67	1.33
October	43.083	.70	1.28
November	30.727	.51	1.11
December	19.642	.32	.98
Total to Date	1,509,517	28.43	66.02
Average		0.68	1.57

TABLE V1-6
MONTHLY HYDRAULIC LOAD AND INFILTRATION RATES FOR BASIN NO. 7

Date	Vol. of Water Applied Acre Feet	Ave. Hydraulic Load feet/day	Ave. Infiltration Rate feet/day
Reclaimed Water			
January 1966	32.866	.49[a]	.70
February	34.538	.46	.77[bc]
March	19.731	.24	1.05
April	17.999	.23	.98
May	18.050	.22	1.10
June	21.413	.26	1.00
July	8.708	.29[d]	.97
August	26.090	.31	.94
September	28.112	.35	1.03
October	27.239	.23	1.00
November	23.268	.29	.94
December	26.527	.45[e]	1.18
January 1967	45.848	.55	.89
February	46.140	.60	.83
March	48.368	.58	.62
April	30.482	.38	.64
May			
June			
July	29.553	.35	.97
August			
September	7.382	.55[f]	1.28
October	3.394	.42[g]	1.26
November	73.538	.91	1.18
December	31.866	.38	.74
January 1968	32.641	.39	.69
February	26.927	.34	.71
March	24.173	.30	.51
April	30.482	.37	.58
May	33.480	.40	.62
June	30.780	.38	.65
July	33.678	.40	.78
August	35.263	.42	.73
September	39.707	.49	.86
October	34.561	.41	.80
November	31.798	.39	.74
December	26.784	.32	.67
Total to Date	981.386	13.15	28.41
Average		0.40	0.86

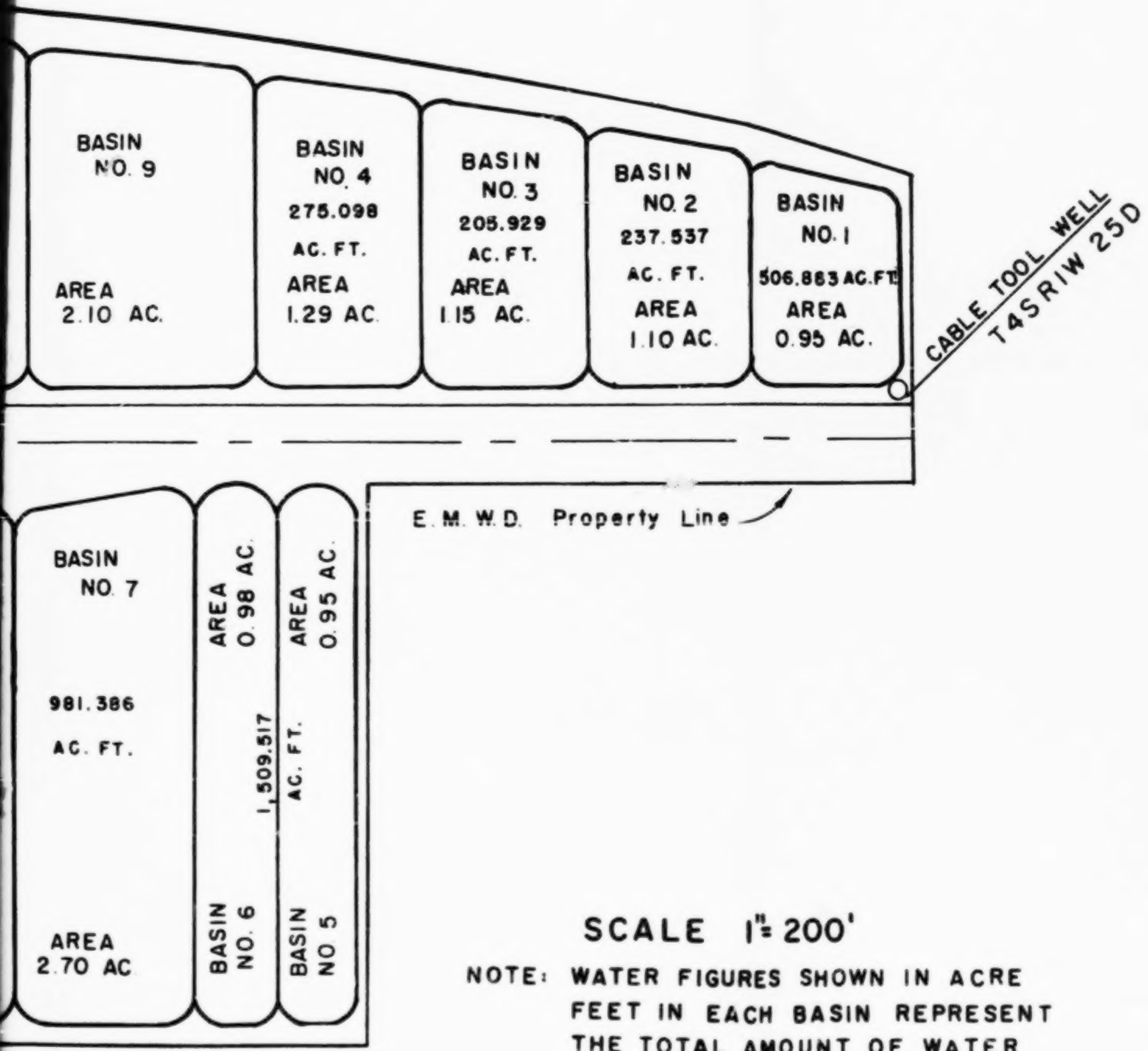
Area = 2.70 acre

a Began spreading January 7, 25 days in month
b Began spreading every 4th day, March 3
c Basin scarified
d 11 days in month
e 22 days in month
f 5 days in month
g 3 days in month


T4S R1W 23 R1
BASIN NO. 10
AREA 1.98 AC.
BASIN NO. 9
AREA 2.10 AC.
BASI
NO.
275.0
AC. F
AREA
1.29 A
℄ Olmstead Ave.
℄ New York Ave
BASIN NO. 8
AREA 2.75 AC
BASIN NO. 7
981.386 AC. FT.
AREA 2.70 AC
AREA 0.98 AC
1,509.517 AC. FT.
BASIN NO. 6
AREA 0.95 AC.
BASIN NO. 5
REPLENISHMENT AREA
SAN JACINTO
SAN JACINTO ST
FLORIDA AVE
HEMET

A

FIGURE VI-1


BASIN NO. 9
AREA 2.10 AC.
BASIN NO. 4
275.098 AC. FT.
AREA 1.29 AC.
BASIN NO. 3
205.929 AC. FT.
AREA 1.15 AC.
BASIN NO. 2
237.537 AC. FT.
AREA 1.10 AC.
BASIN NO. 1
506.883 AC. FT.
AREA 0.95 AC.
CABLE TOOL WELL
T4S R1W 25D
E. M. W. D. Property Line
BASIN NO. 7
981.386 AC. FT.
AREA 2.70 AC
AREA 0.98 AC.
AREA 0.95 AC.
1,509.517 AC. FT.
BASIN NO. 6
BASIN NO. 5

SCALE 1" = 200'

NOTE: WATER FIGURES SHOWN IN ACRE FEET IN EACH BASIN REPRESENT THE TOTAL AMOUNT OF WATER WHICH HAS INFILTRATED EACH BASIN

REPLENISHMENT AREA

B

EUGENE DIETZGEN CO.
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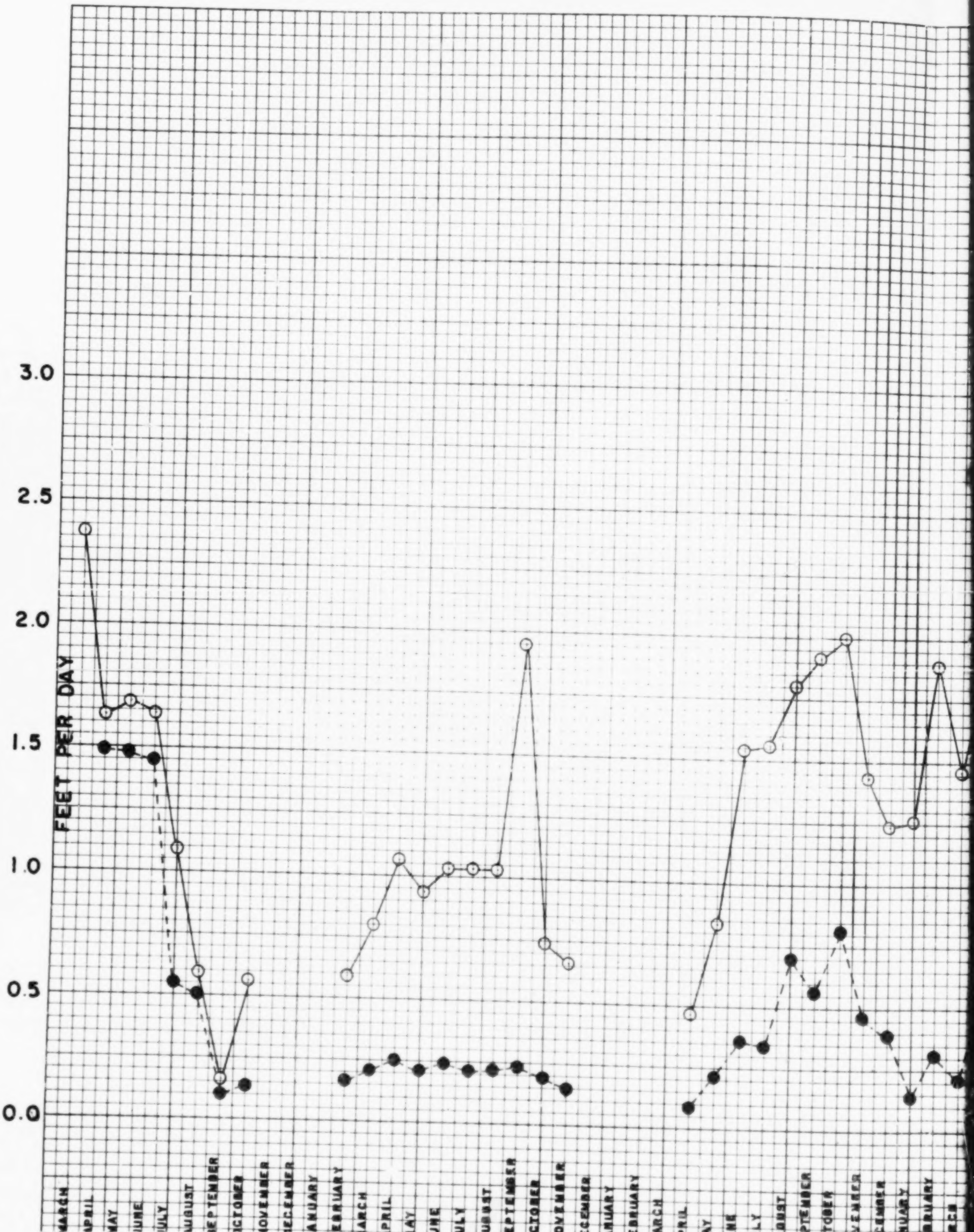

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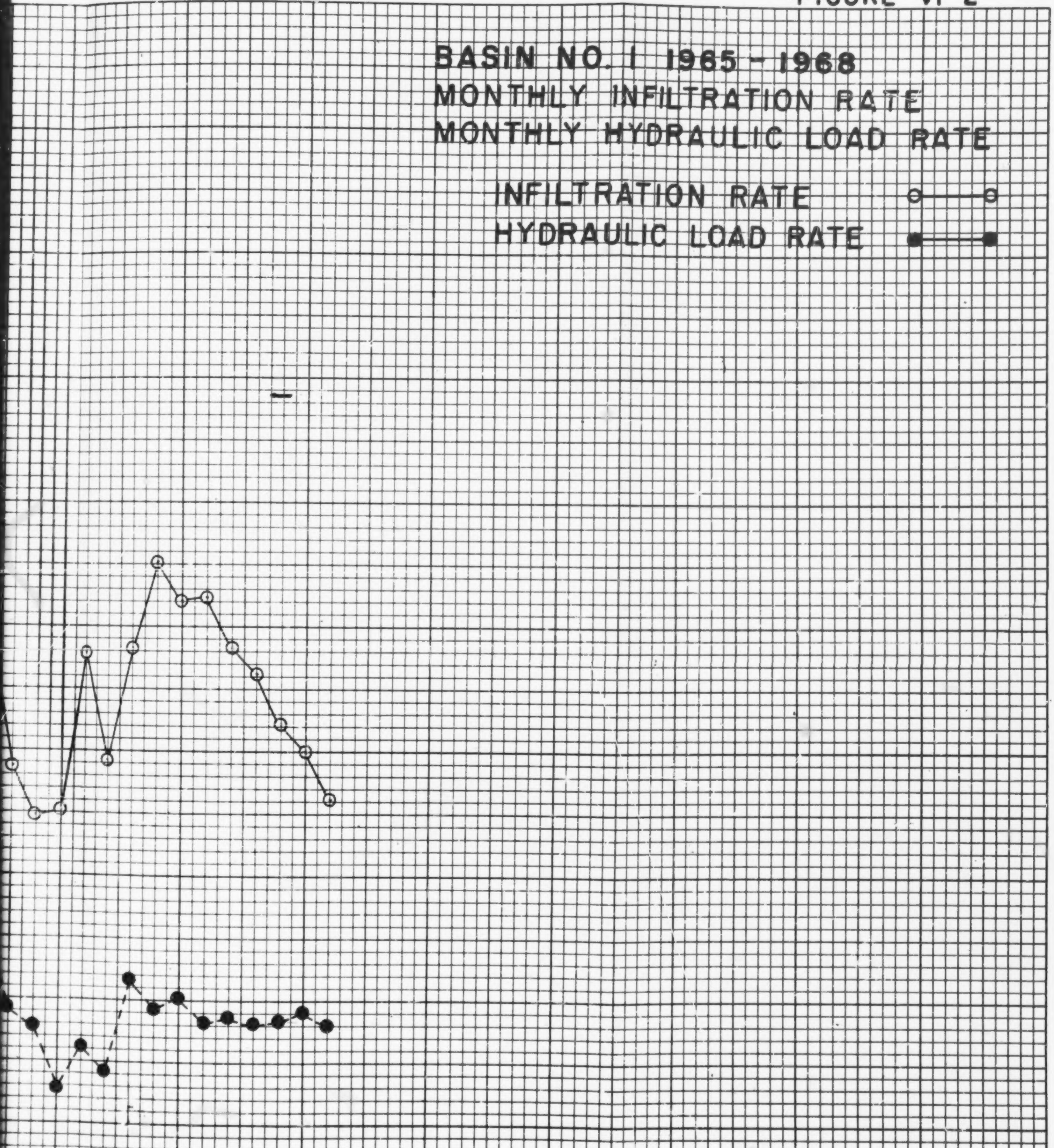
FIGURE VI-2


BASIN NO. 1 1965 - 1968
MONTHLY INFILTRATION RATE
MONTHLY HYDRAULIC LOAD RATE
INFILTRATION RATE ○—○
HYDRAULIC LOAD RATE ●—●
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
1968

B

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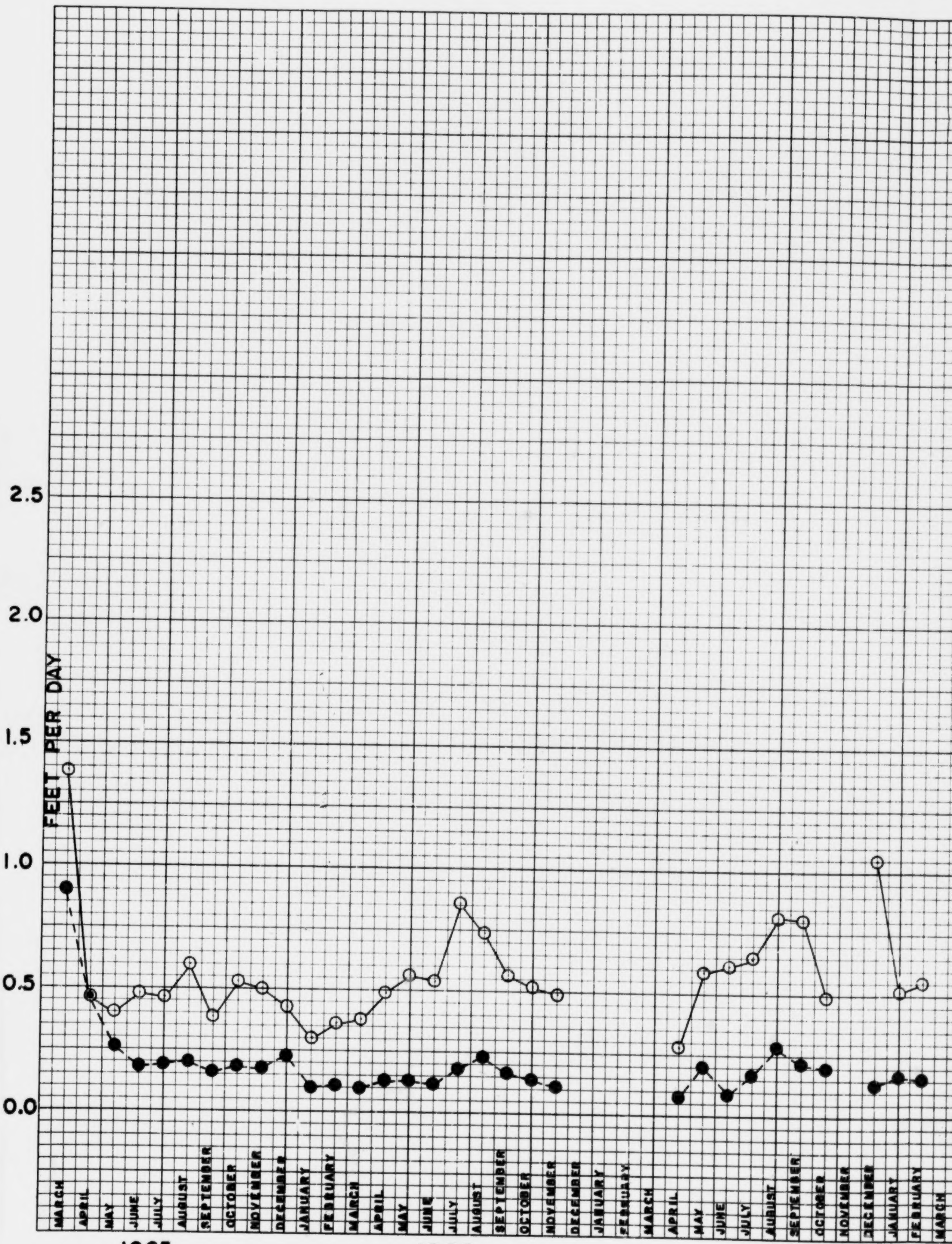

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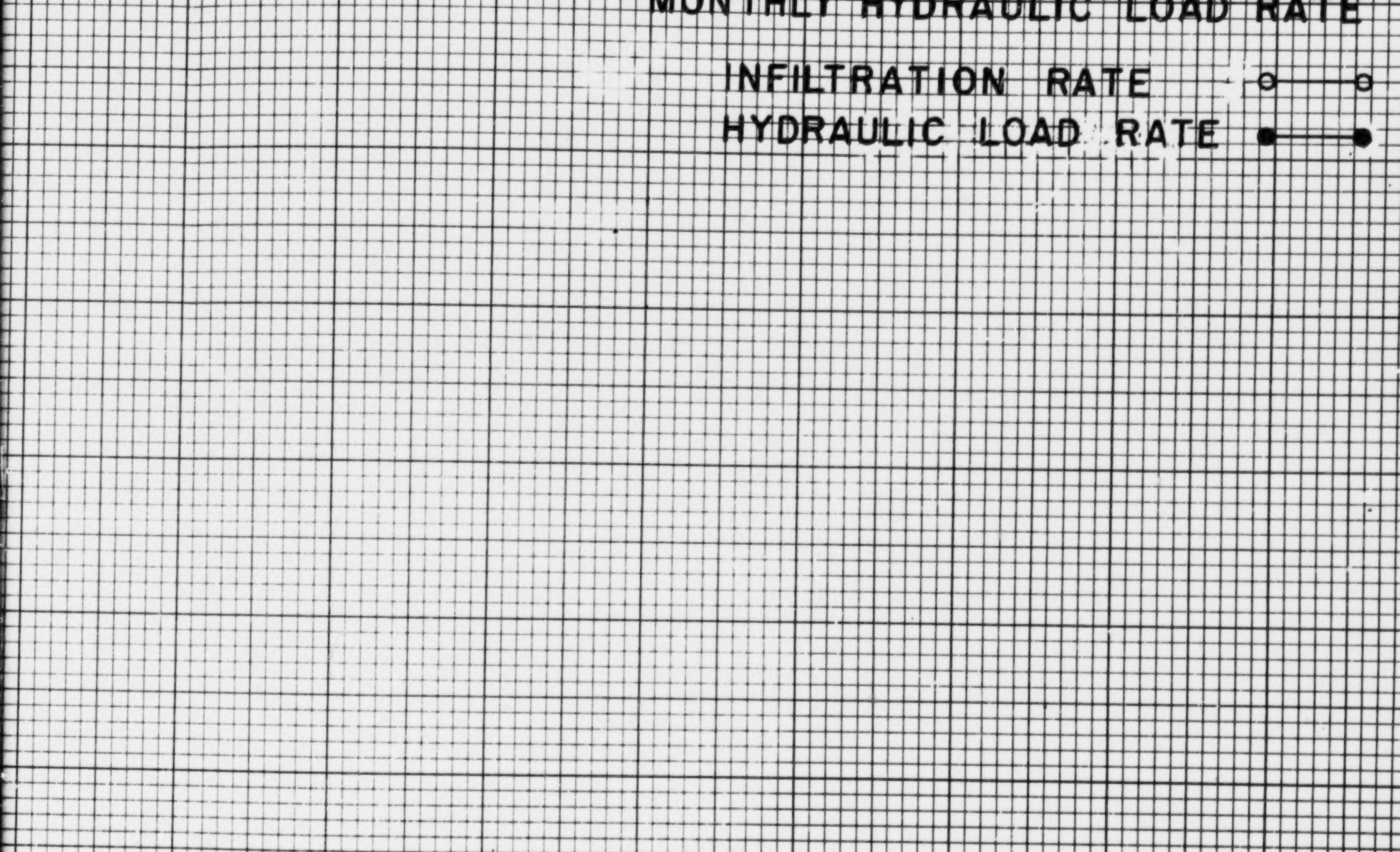
FIGURE VI-3



BASIN NO. 2 1965 - 1968
MONTHLY INFILTRATION RATE
MONTHLY HYDRAULIC LOAD RATE

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NO. 340DR-10 DIETZGEN GRAPH PAPER
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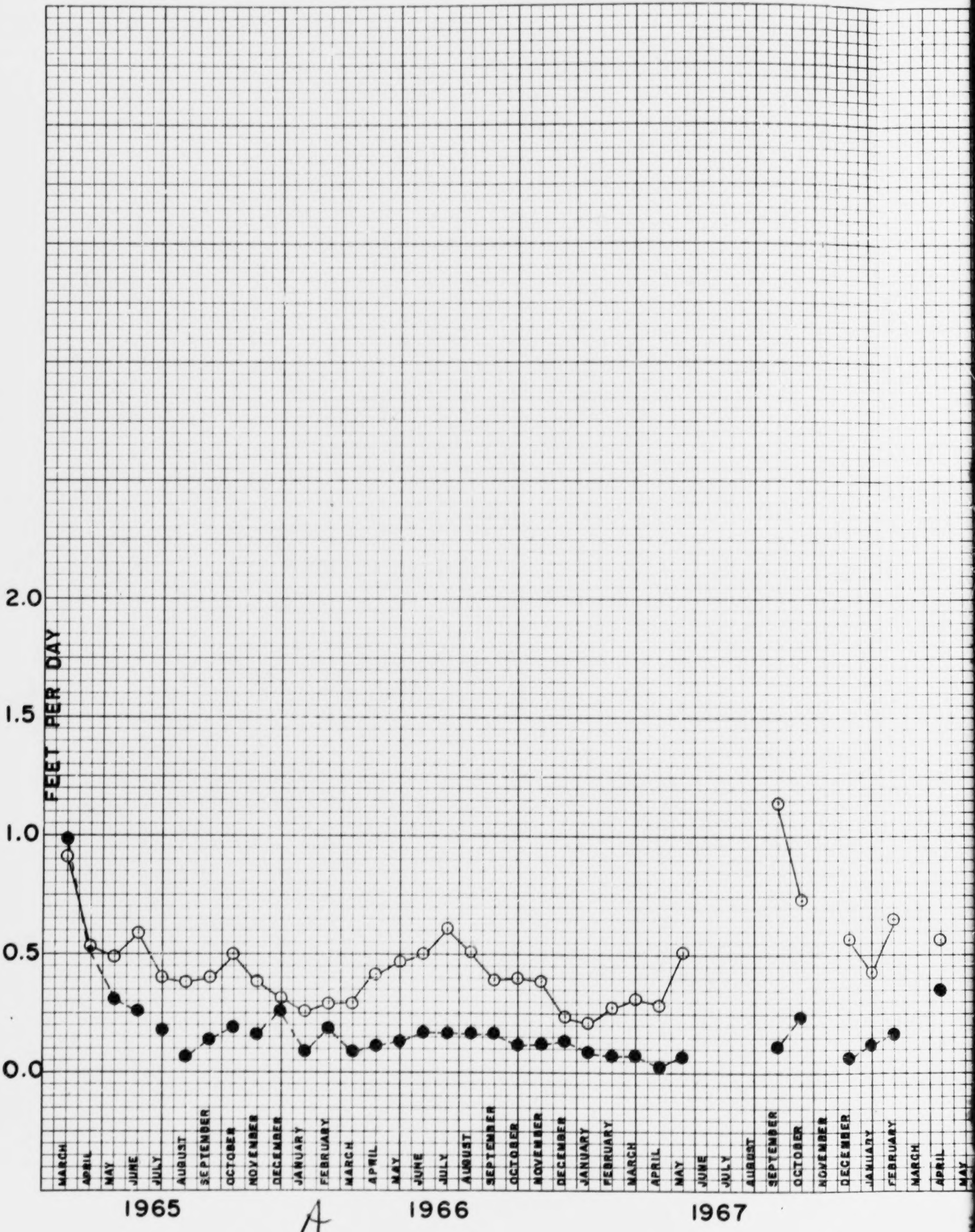

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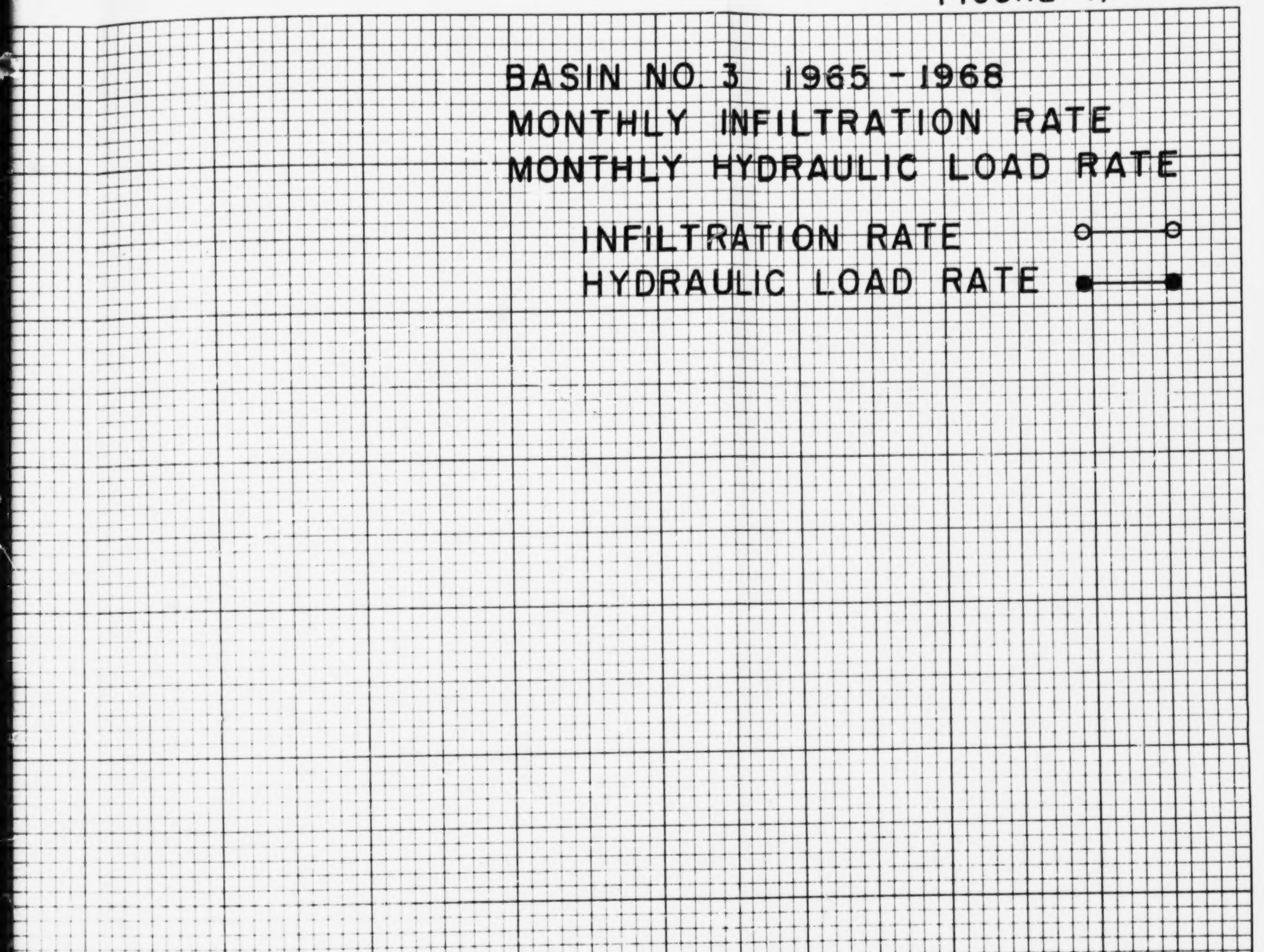
FIGURE VI- 4


BASIN NO. 3 1965 - 1968
MONTHLY INFILTRATION RATE
MONTHLY HYDRAULIC LOAD RATE

B

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10 X 10 PER INCH

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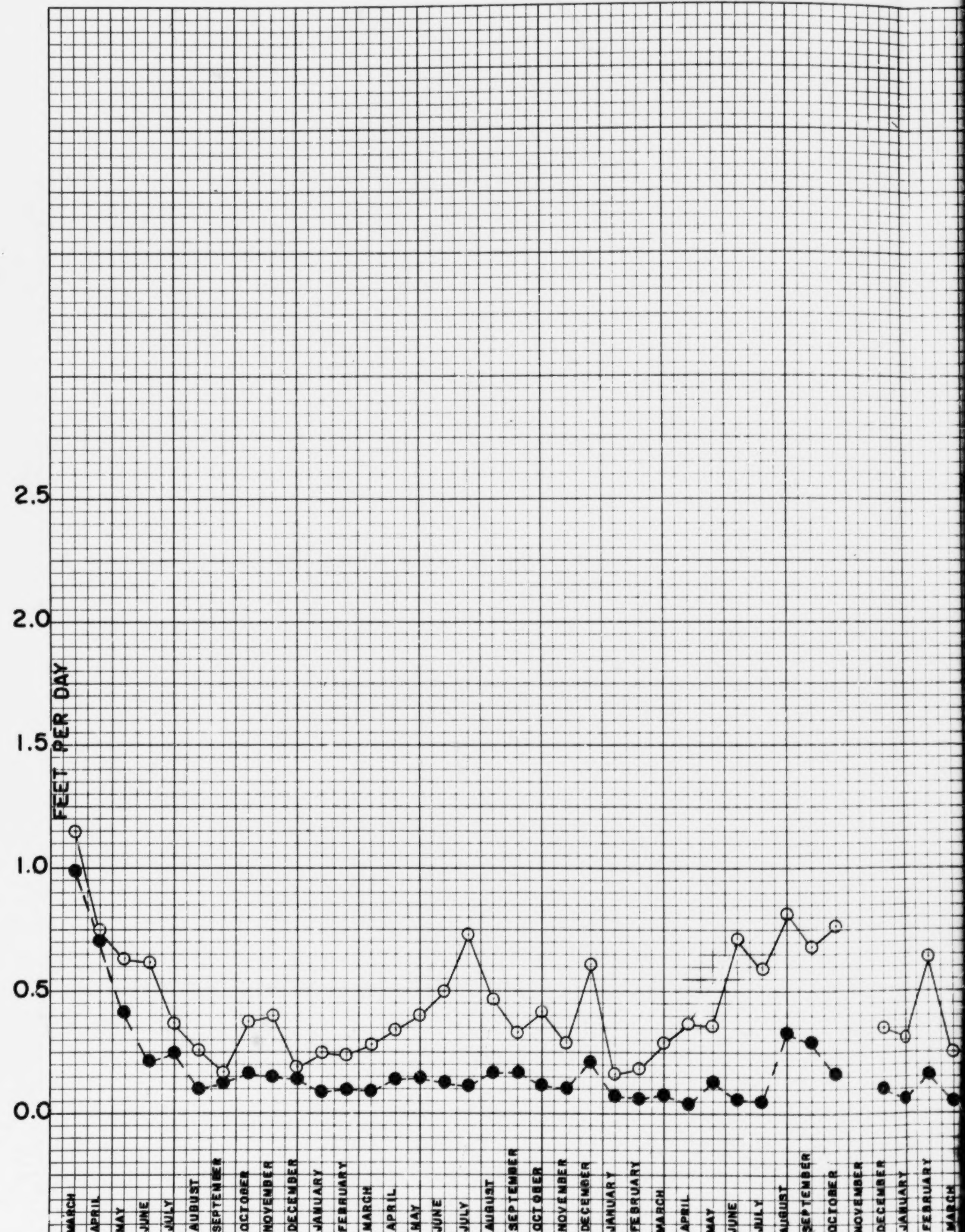

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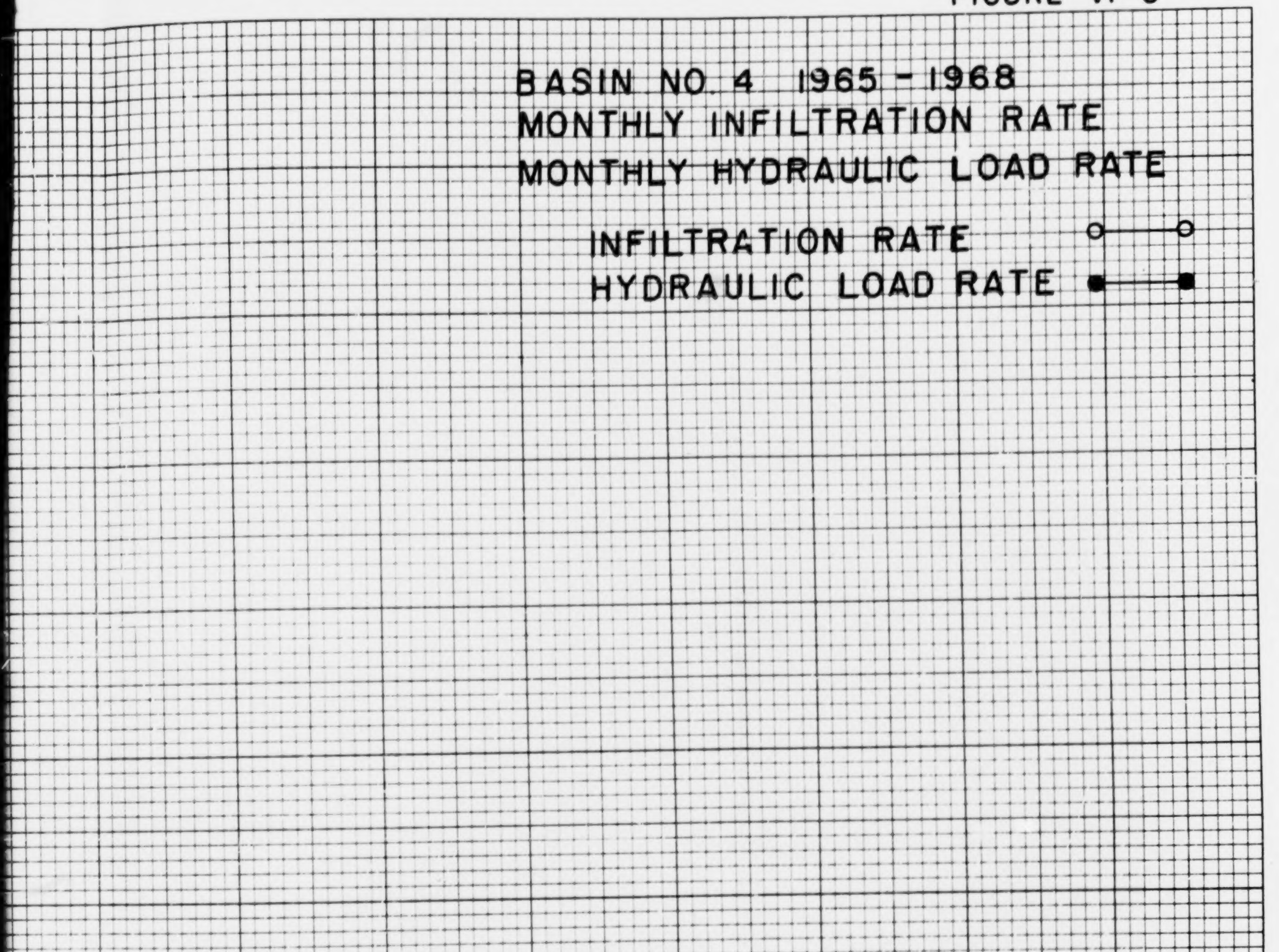
FIGURE VI- 5



BASIN NO. 4 1965 - 1968
MONTHLY INFILTRATION RATE
MONTHLY HYDRAULIC LOAD RATE

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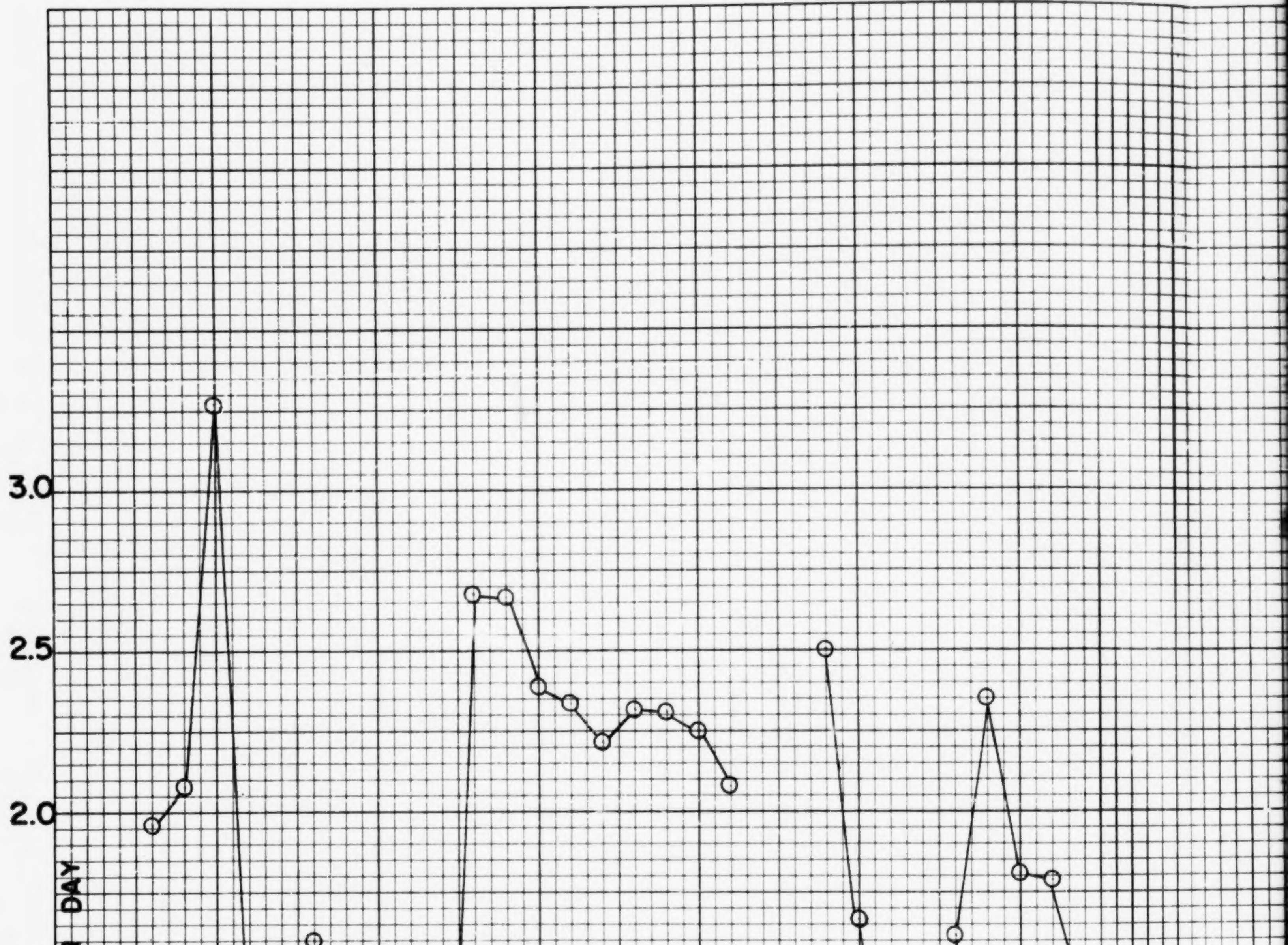

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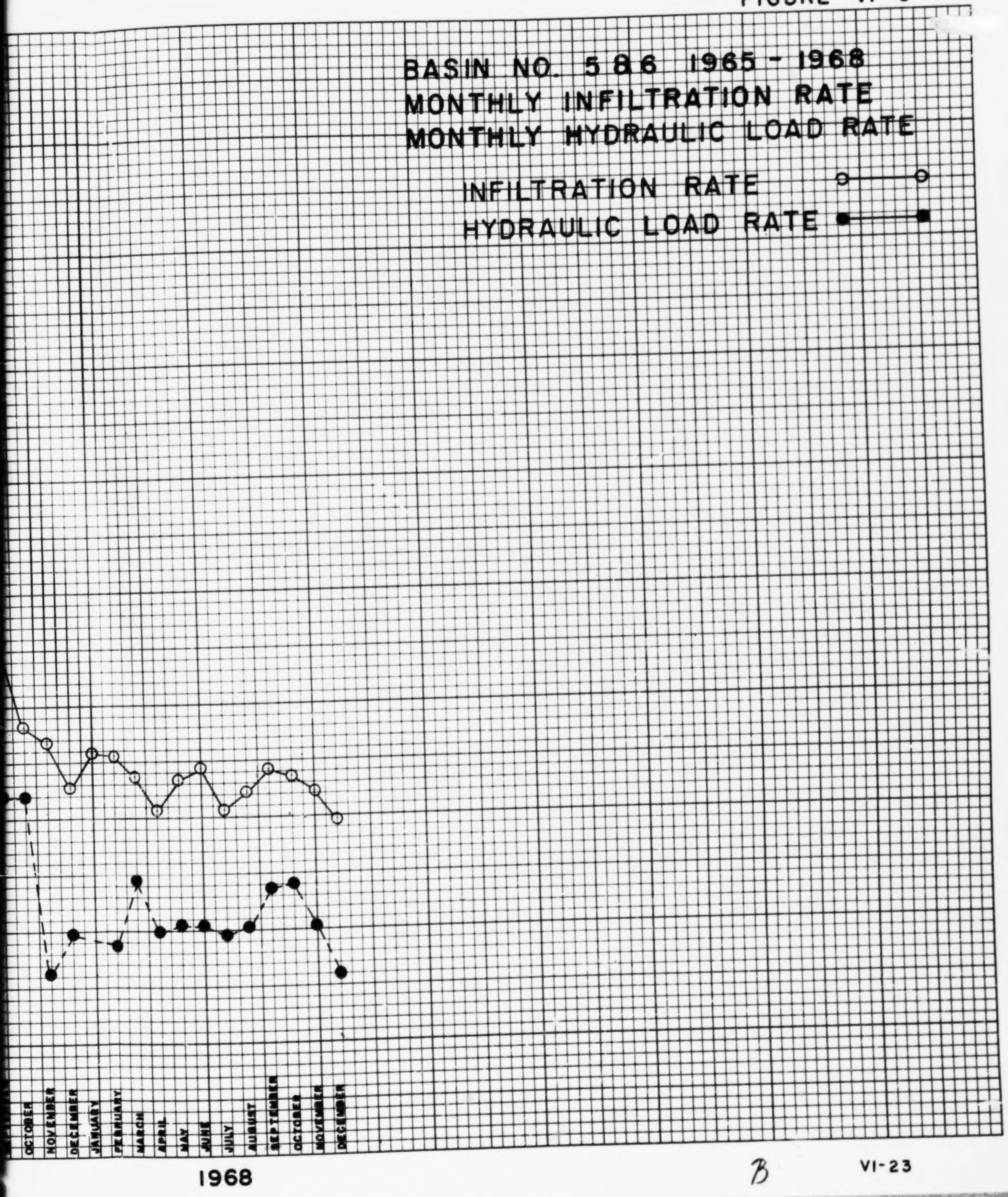
FIGURE VI- 6



BASIN NO. 5 & 6 1965 - 1968
MONTHLY INFILTRATION RATE
MONTHLY HYDRAULIC LOAD RATE

B

NO. 340DR-10 DIETZGEN GRAPH PAPER
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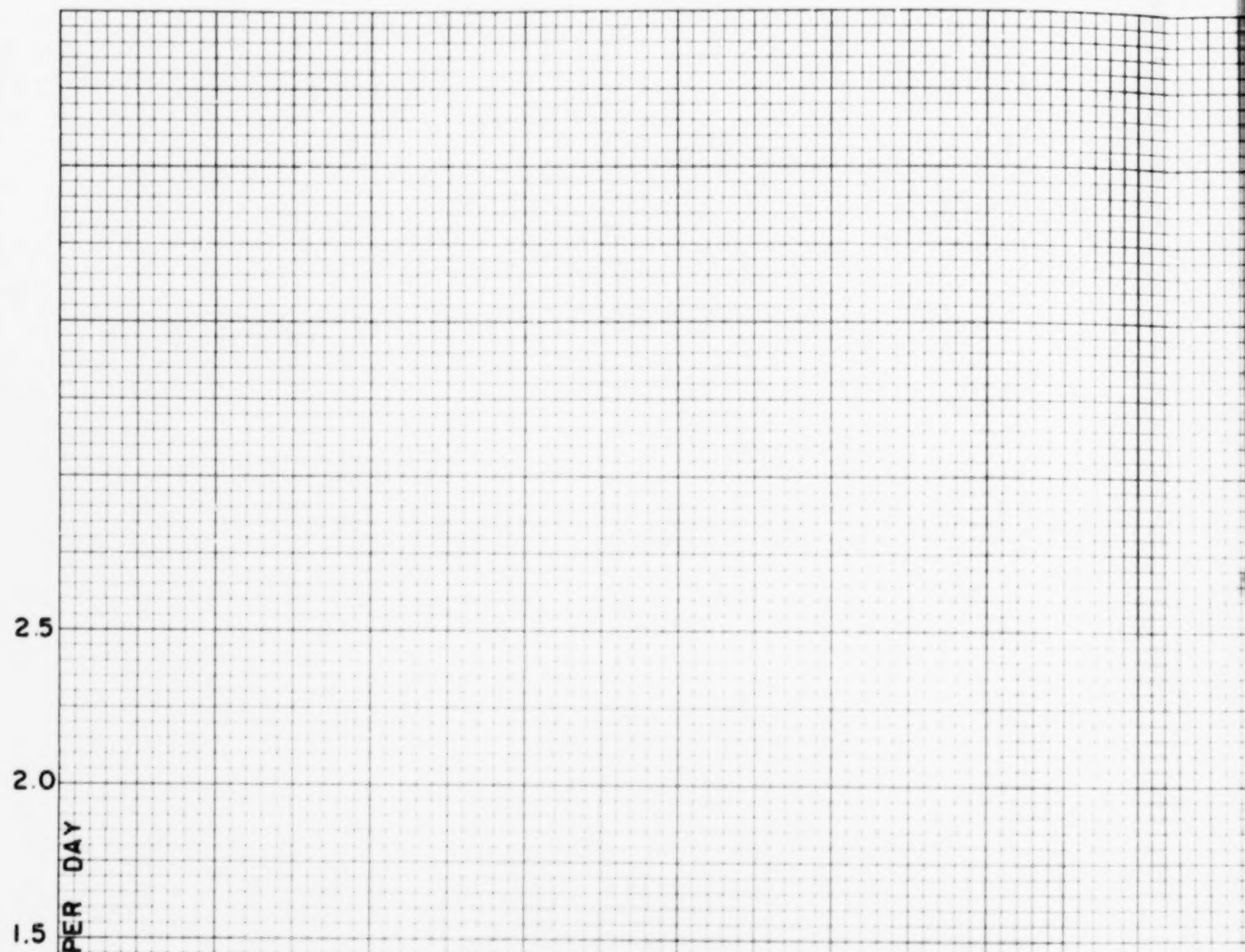

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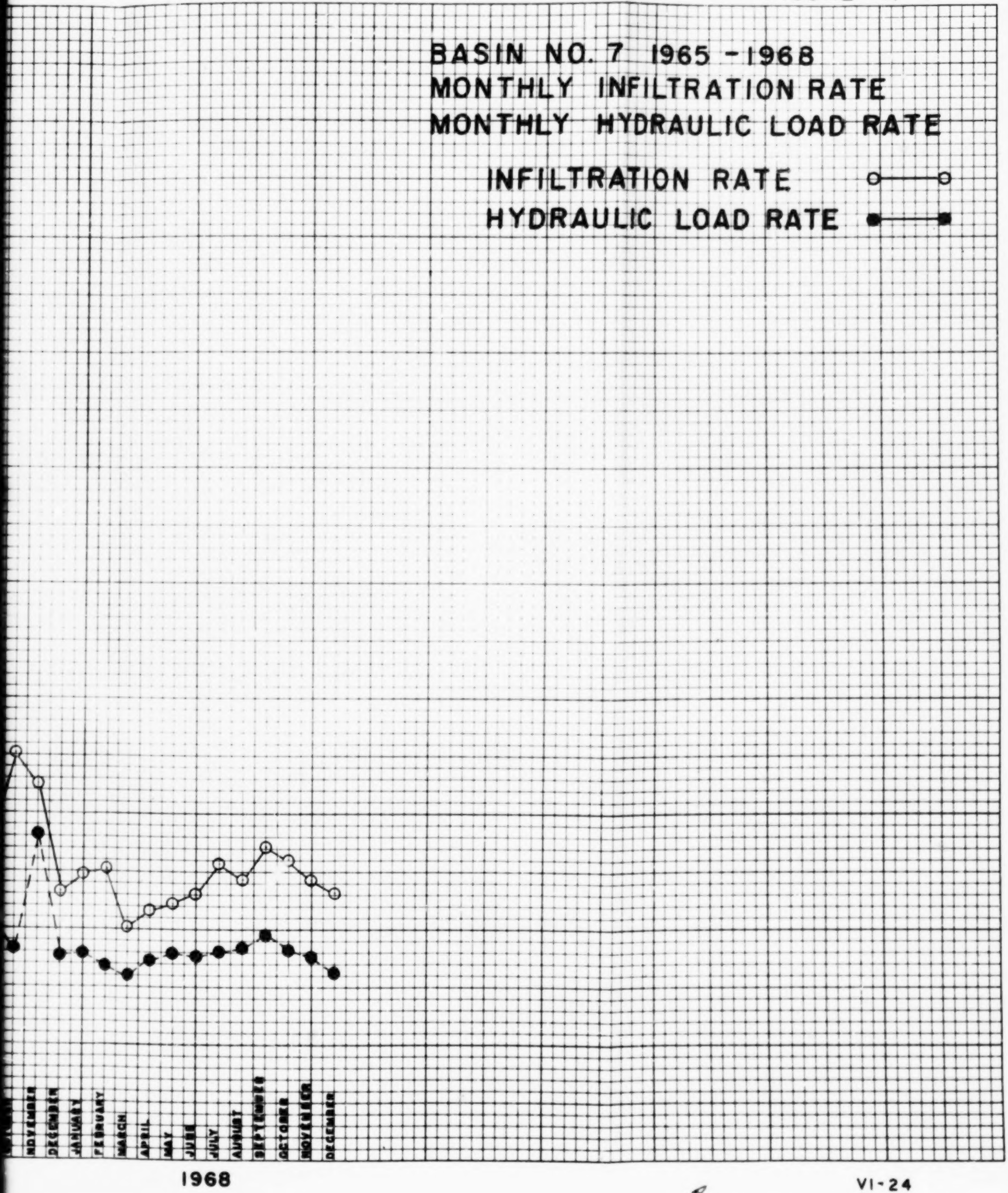
FIGURE VI-7



BASIN NO. 7 1965 - 1968
MONTHLY INFILTRATION RATE
MONTHLY HYDRAULIC LOAD RATE

B

CHAPTER VII

SAMPLING PANS

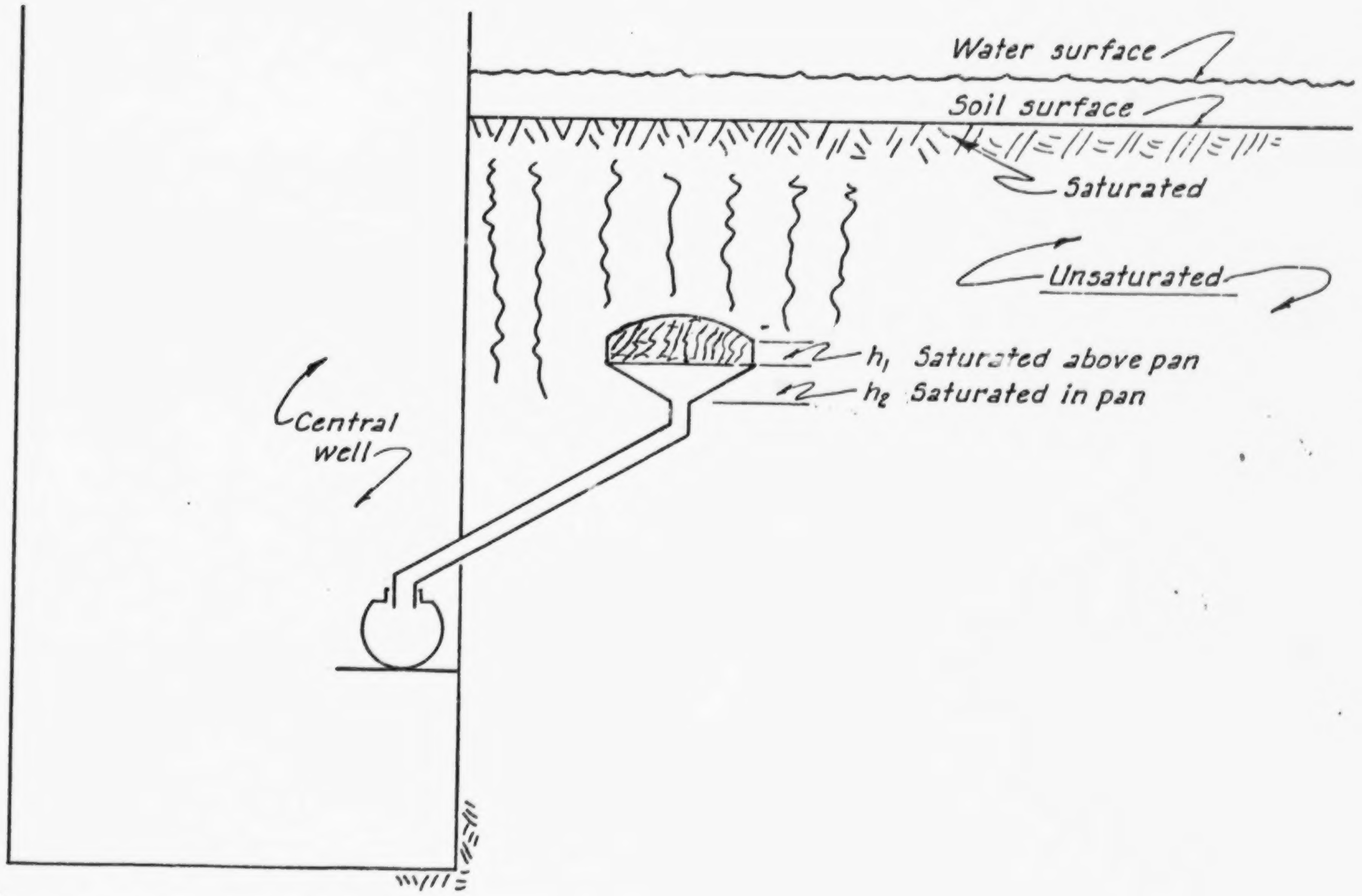
An understanding and delineation of the various physical, chemical and biochemical changes occurring in the reclaimed water as it percolates through the ground is one of the prime purposes of this project. These changes are a function of many things; e.g., dissolved oxygen concentration, bacterial population, time, type of soil, etc. Comparing analyses of representative water samples obtained from the water being spread and after it reaches a nearby water well will show the overall water quality changes. But this comparison will not show all of the intermediate changes which have occurred nor will this method produce sufficient data to indicate the reasons for these changes.

The intermittent spreading cycle produces a soil moisture profile which shows the soil to be completely saturated at the soil water interface, and unsaturated from there down to ground water. Since many of the water quality changes occur in the unsaturated zone, it is advantageous to obtain representative water samples from this zone. Sampling "pans" were designed and installed in Spreading Basin No. 1 to serve this purpose.

Parameters and Bases for Design of Sampling Pans

Theoretically, water percolating through unsaturated soil is flowing at less than atmospheric pressure. Because of this, tensiometers were originally considered for sampling, but were rejected because they filter various organisms from the sample. Other devices for obtaining water from unsaturated soil were considered, but each device had one or more problems associated with its use.

The device which offered the most promise was a funnel or pan installed in the soil to capture percolating water and drain it to a central well. Without a vacuum, these pans theoretically wouldn't function, due to pressure differences between atmospheric pressure in the central well and soil pore pressures. Since pans of this type captured water in the past(10) it was thought that water saturated the soil above the pan to some height giving sufficient head to overcome the pressure difference between atmospheric and soil pan pressure. The following sketch depicts the situation which would be necessary to obtain a sample of percolating water from an unsaturated soil.



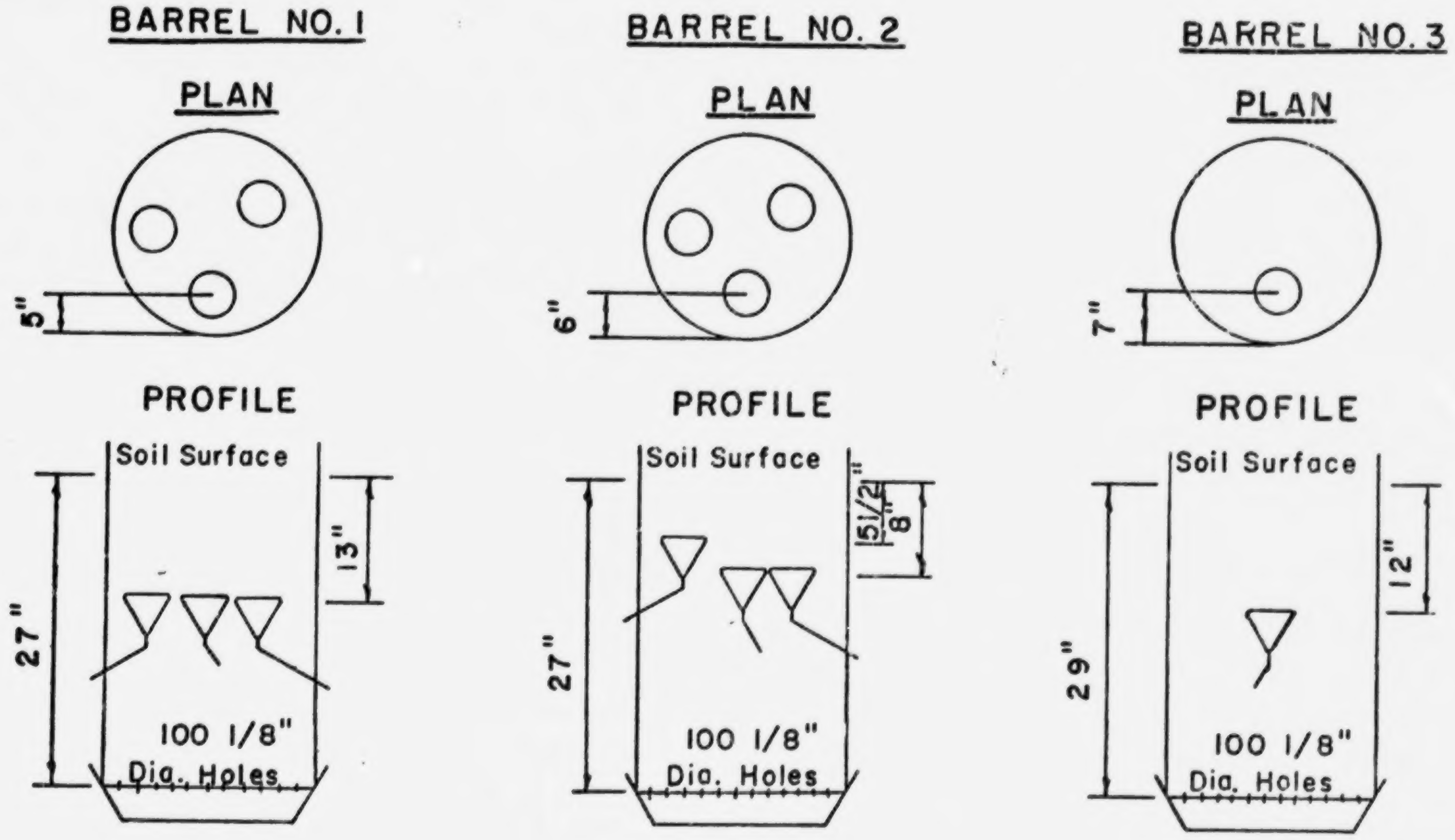
However, a problem occurs if water is obtained by the method detailed in the above sketch. This saturated zone both above and in the pan can hold a considerable amount of water, thereby causing a long delay in getting the water into the sampling pan. For example, if one foot of water is pumped into the basin and h_1 is 3 inches, porosity is 40% and the pan diameter is 2 feet, then the volume of water held in the saturated zone above the pan is 2.35 gallons. If each day that water is pumped into the basin only 1 gallon of water passes through the sampling pan, the detention time in the saturated zone above the pan is 2.35 days, in addition to the number of days the basin is allowed to dry. The knowledge of the amount of water held in the saturated zone is very important to correctly interpreting many of the physical and biochemical changes occurring in the water.

It was decided to attempt to reduce the saturated zone above a pan, thereby shortening the detention time and producing a more representative sample of the actual percolating water. It was thought that different materials in a pan would influence any saturated zone above the pan and yield different detention times and different volumes of water.

Model studies were conducted to determine the best pan media that gave the lowest detention time and highest yield of water. The theoretical maximum volume of water which could be obtained from a pan is equal to the height of water applied to the soil times the cross-sectional area of the pan. The theoretical minimum detention time could not be easily computed as the water percolates through a short saturated zone and then through an unsaturated zone before it reaches a pan.

Model Study

Pans were made and placed in three fifty-five gallon drums. The pans were placed in each drum such that comparison of data from the drums might indicate sidewall influence, if any, and detention time in a saturated zone. Schematics of the three barrels are shown below:


BARREL NO. 1
PLAN
5"
PROFILE
Soil Surface
27"
13"
100 1/8"
Dia. Holes
BARREL NO. 2
PLAN
6"
PROFILE
Soil Surface
5 1/2"
8"
27"
100 1/8"
Dia. Holes
BARREL NO. 3
PLAN
7"
PROFILE
Soil Surface
29"
12"
100 1/8"
Dia. Holes

Barrel Dia. = 22" Area = 379.9"	**Barrel Dia = 22" Area = 379.9"**	**Barrel Dia = 22" Area = 379.9"**
Funnel Dia = 6" Area = 28.3"	**Funnel Dia = 6" Area = 28.3"**	**Funnel Dia. = 6" Area = 28.3"**
Total Funnel Area = 22.3% of Barrel Area	**Total Funnel Area = 22.3% of Barrel Area**	**Total Funnel Area = 7.4% of Barrel Area**

Each barrel was filled with soil obtained from the spreading basins and random samples were selected for constant head permeability tests.(11) The results of these permeability tests shown on the following page in centimeters per second and feet per day. The porosities, which ranged from 0.37 to 0.38, are also typical of sand.

Permeability Test

Sample	Results	
	cm/sec.	ft. /day
A	1.691×10^{-2}	47.8
B	1.356×10^{-2}	38.4
C	0.572×10^{-2}	16.2
D	6.02×10^{-2}	170.0

The first series of tests were run in Barrel No. 1 and the pans were filled with the same material as the barrels. Table VII-1 shows the results.

The second series of tests were run in Barrel No. 1 after the material was replaced with new soil from the spreading basins. The material in the pans was replaced with graded rock and gravel from 1/4 to 1 inch in size filled approximately 2 inches above the pan top. The third series of tests were run with replaced soil in Barrel No. 1, using glass wool in the pans. Table VII-2 shows the results of both the second and third series of tests.

In addition to the results shown in Tables VII-1 and VII-2, 23 additional tests were run in Barrel No. 1 with glass wool as the medium in the pans. The percent recovery for all 23 tests was 17.8. Ten additional tests were run in Barrel No. 2 using glass wool in the pans with a 17.6 percent recovery factor. The significance of the percent recovery factor as defined in Tables VII-1 and VII-2 is demonstrated by comparing the volume of water passing through the pans having different media. If the percolating water flowed without effect from the pans or barrel sides, each pan should capture 7.43% of the total water recovered. With either sandy soil or rock in the pans, the percent recovery was very low, 2.1% and 1.2% respectively, but with glass wool, the recovery factor was over 77 percent of the area actually occupied by the pans.

While this recovery factor doesn't necessarily indicate a very small detention time in some saturated zone above a pan, it does indicate a minimum detention time assuming any given saturated zone for any pan regardless of media.

All of the above model studies were run outside without control for evaporation. During each change of soil in a barrel the soil above the funnels did not appear saturated while the soil in the bottom was definitely saturated.

An attempt was made to measure the detention time in the soil column. As a base, 80 liters Colorado River water were run through Barrel No. 3. The chloride concentration in the 80 liters averaged 109 mg/l and ranged from 107 mg/l to 113 mg/l. Following this, 14 liters of water with a chloride ion concentration of 500 mg/l were run through the barrel. Water captured by the pan was analyzed for chlorides and a plot of this information is shown in Figure VII-1. While it is very difficult to determine the detention time in the saturated zone above any pan, Figure VII-1, together with the high percent recovery indicates that the detention time is much less than one day. Indeed, since the arrival time of the chloride ion can be measured in hours, it was expected that full scale pans with glass wool as a medium would function within the same time range.

A comparison of the permeability tests to the actual arrival time of the water during model studies show little correlation. However, this lack of correlation wasn't unexpected, as the permeability tests use a constant head of water; thus, they measure flow rates through saturated soil, whereas the model studies were intended to sample water from unsaturated soil and they indicate detention time for water which has flowed through saturated and unsaturated soil.

Several additional attempts were made to establish detention times in the soil. One attempt was made by adding 14 liters of distilled water to a barrel, following by 14 liters of Colorado River water to which fluoride had been added. The amount of fluoride added to the Colorado River water increased the fluoride concentration to 2.2 milligrams per liter. The fluoride concentration in the water obtained from the funnels ranged from 0.85 mg/l to 1.00 mg/l with an average of 0.91 mg/l. Ten samples of water from the bottom of the barrel were obtained and fluoride content ranged from 1.00 mg/l to 1.05 mg/l. A second attempt was made by adding another 14 liters of distilled water to the same barrel followed by 14 liters of Colorado River water to which sulfate had been added. A correlation between the high sulfate concentration water added and the water obtained from either the funnels or the bottom of the barrel was not possible.

As a final check of the suitability of glass wool, sewage effluents were run through Barrel No. 3. Coliform counts over 18,000 mpn were recorded.

Design and Construction

The model studies were conclusive and spun glass wool was used in the pans in spreading basin No. 1. The design of the sampling pan structure was based on material which was on hand. The District had a scrap piece of 8-foot diameter steel pipe which was placed in an excavation with a poured concrete floor. A flat piece of steel was welded to the top and a small pipe was used as a hatch to extend the entryway above ground and/or future water surface level.

There are many questions concerning the "ripening" of an intermittently spread basin. At the time of construction, spreading basin No. 1 had been ripening for 13 months. Two pans were set at each level below the soil surface, one pan beneath undisturbed soil and the other in soil which was removed and replaced during installation of the structure. By dual placement of the pans on each level an effort was made to duplicate natural conditions (pans beneath undistrubed soil) and to check as to the need for this highly specialized construction by installing pans under disturbed soil and comparing results.

After installation of the structure was completed, the basin was flooded and the soil around the structure settled severely. Some of the soil load was transferred to the 3/4 inch plastic tubes which connect the pans to the structure causing the tubes to sever their connections at the structure. The soil was re-excavated and repairs were made. After re-compaction, what little settlement that did occur did not cause any apparent damage to the system. A schematic of the Sampling Pan Installation is shown on Figure VII-1.

A graph for 1967-68 of the amount of water recovered through all of the pans is shown on Figure VII-3. It is interesting to note that recovery rates for all of the installed sampling pans exceed 90% of the theoretical recovery. The model studies closely predicated recoveries for the actual installation and the pans are functioning very well.

Table VII-1

PARAMETERS AND BASES FOR DESIGN OF SAMPLING PANS

Model Studies

Run No. 1
Basin Soil in Pans in Barrel No. 1

Test No.	Hrs. between Adding water	Amount Added (ml)	Amount Recovered Pan #1	Pan #2	Pan #3	Bottom	% Pan recovery[(a)]
1-A		50,000	84	115	116		
1-B	4	7,000	0	0	105		
1-C	1	7,000	11	13	66		
1-D	42	14,000	42	10	128		
1-E	6	7,000	0	0	10		
1-F	19	14,000	74	59	170		
1-G	2-1/2	14,000	70	48	140		
1-H	114	14,000	18	41	39		
Total		127,000	299	284	774	63,615(b)	2.1 ave.

(a) Percent pan recovery is equal to the ratio of amount recovered by all pans to the amount recovered by pans and from the bottom.

(b) Amount of water recovered from bottom of the pans was recorded for each test, but the individual recordings were in error due to sand plugging the drain. However, the figure for the total amount recovered from the bottom is correct.

Table VII-2

PARAMETERS AND BASES FOR SAMPLING PAN DESIGN

Model Study

Run No. 2
Rocks in Pans in Barrel No. 1

Test No.	Hrs. between adding water	Amount Added (ml)	Amount Recovered Pan #1	Pan #2	Pan #3	Bottom	% Pan recovery(a)
2-A		14,000	0	36	0	2,110	
2-B	4	14,000	5	20	6	7,862	
2-C	2-1/2	14,000	24	26	16	15,343	
2-D	17	14,000	9	39	30	8,820	
2-E	2	14,000	67	121	49	12,840	
2-F	2	14,000	68	131	61	14,830	
2-G	42	14,000	5	29	5	9,670	
2-H	4	14,000	68	86	73	10,790	
Total		112,000	246	488	240	82,265	1.2 ave.

Run No. 3
Glass Wool in Pans in Barrel No. 1

Test No.	Hrs. between adding water	Amount Added (ml)	Amount Recovered Pan #1	Pan #2	Pan #3	Bottom	% Pan recovery(a)
3-A		14,000	0	33	5	3,370	
3-B	18	14,000	590	220	440	5,050	
3-C	2	14,000	1210	1060	1000	11,900	
3-D	2	14,000	770	960	740	11,030	
3-E	2-1/2	14,000	740	940	710	14,370	
3-F	17-1/2	14,000	420	520	320	7,000	
3-G	2-1/2	14,000	1090	1100	760	9,960	
3-H	2	14,000	660	810	780	12,000	
3-I	21	14,000	460	410	210	12,910	
3-J	72	14,000	60	185	53	7,000	
Total		140,000	6000	6238	5018	94,590	14.5 ave.

(a) Percent pan recovery is equal to the ratio of amount recovered by all pans to the amount recovered by the pans and from the bottom

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FIGURE VII-1

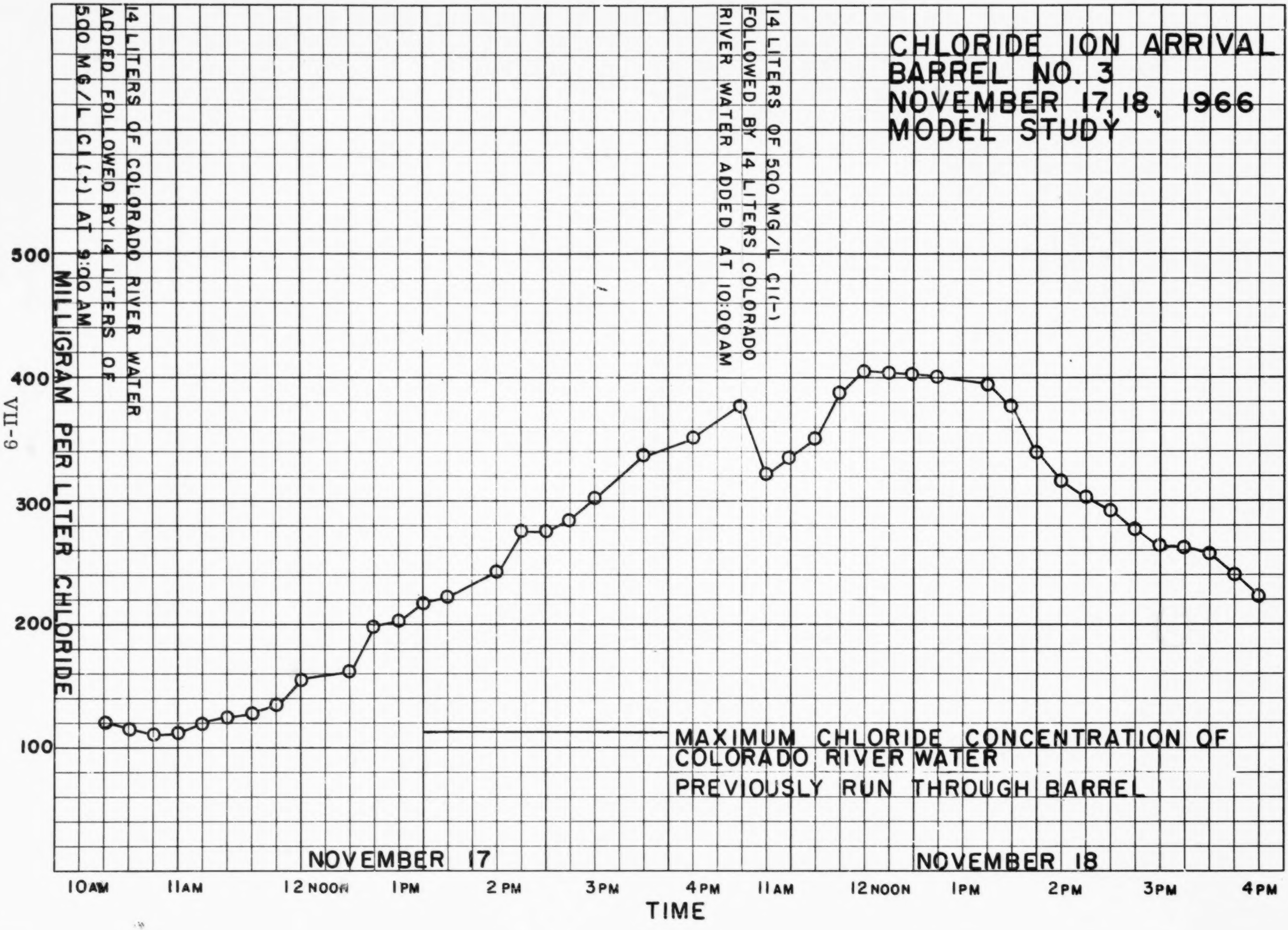
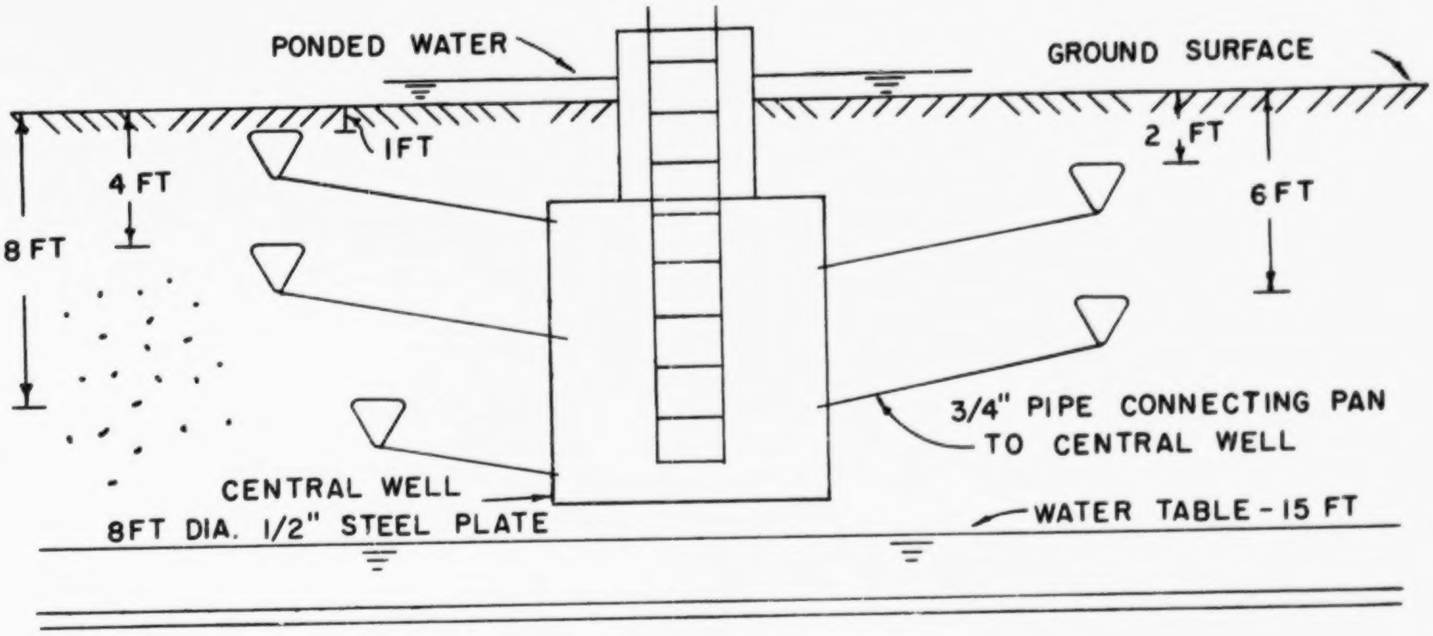


FIGURE VII-2

SCHEMATIC OF SAMPLING PAN WELL


PONDED WATER
GROUND SURFACE
1 FT
4 FT
8 FT
2 FT
6 FT
3/4" PIPE CONNECTING PAN TO CENTRAL WELL
CENTRAL WELL
8 FT DIA. 1/2" STEEL PLATE
WATER TABLE - 15 FT

LAYOUT OF TEST BASIN

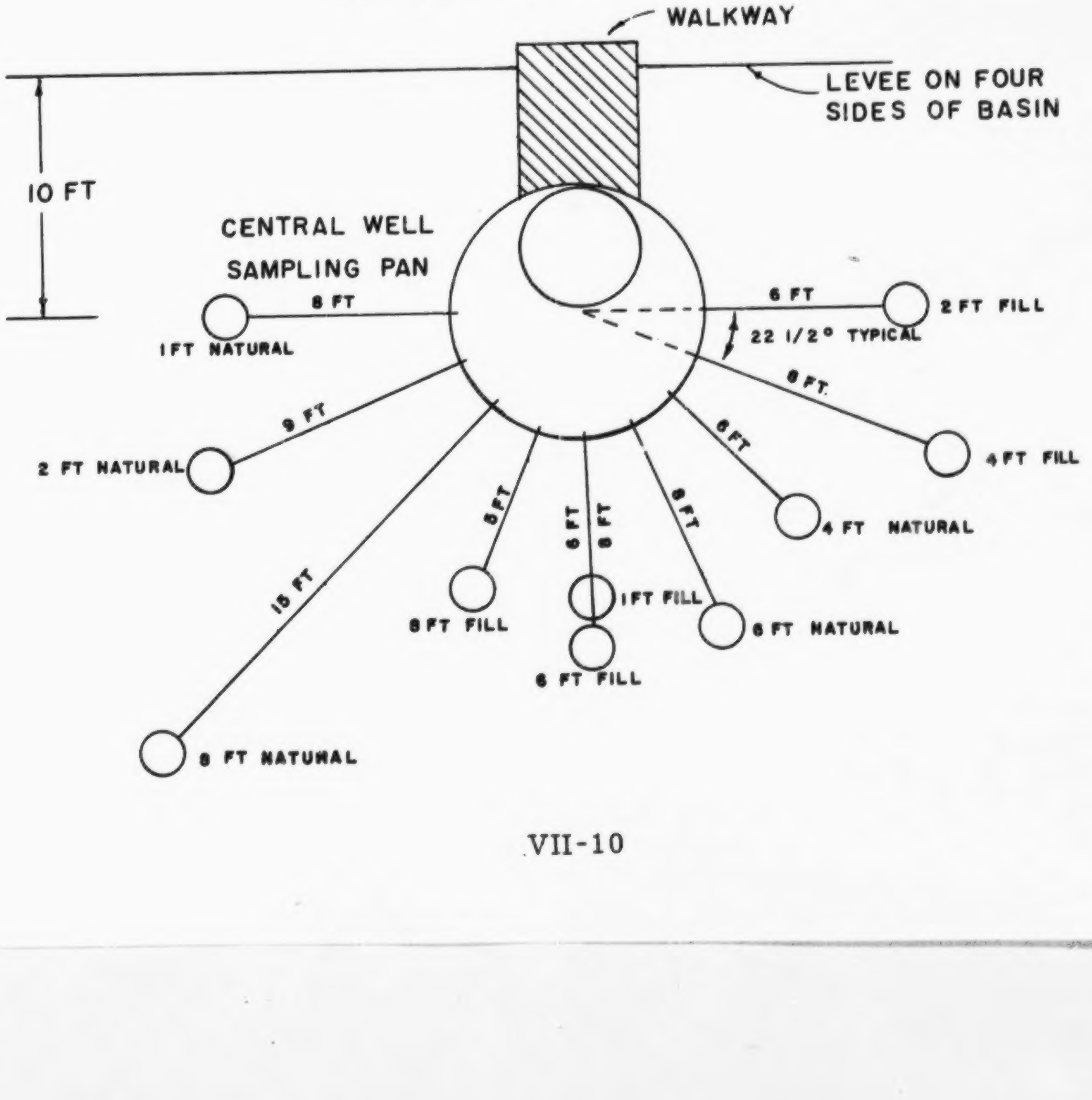
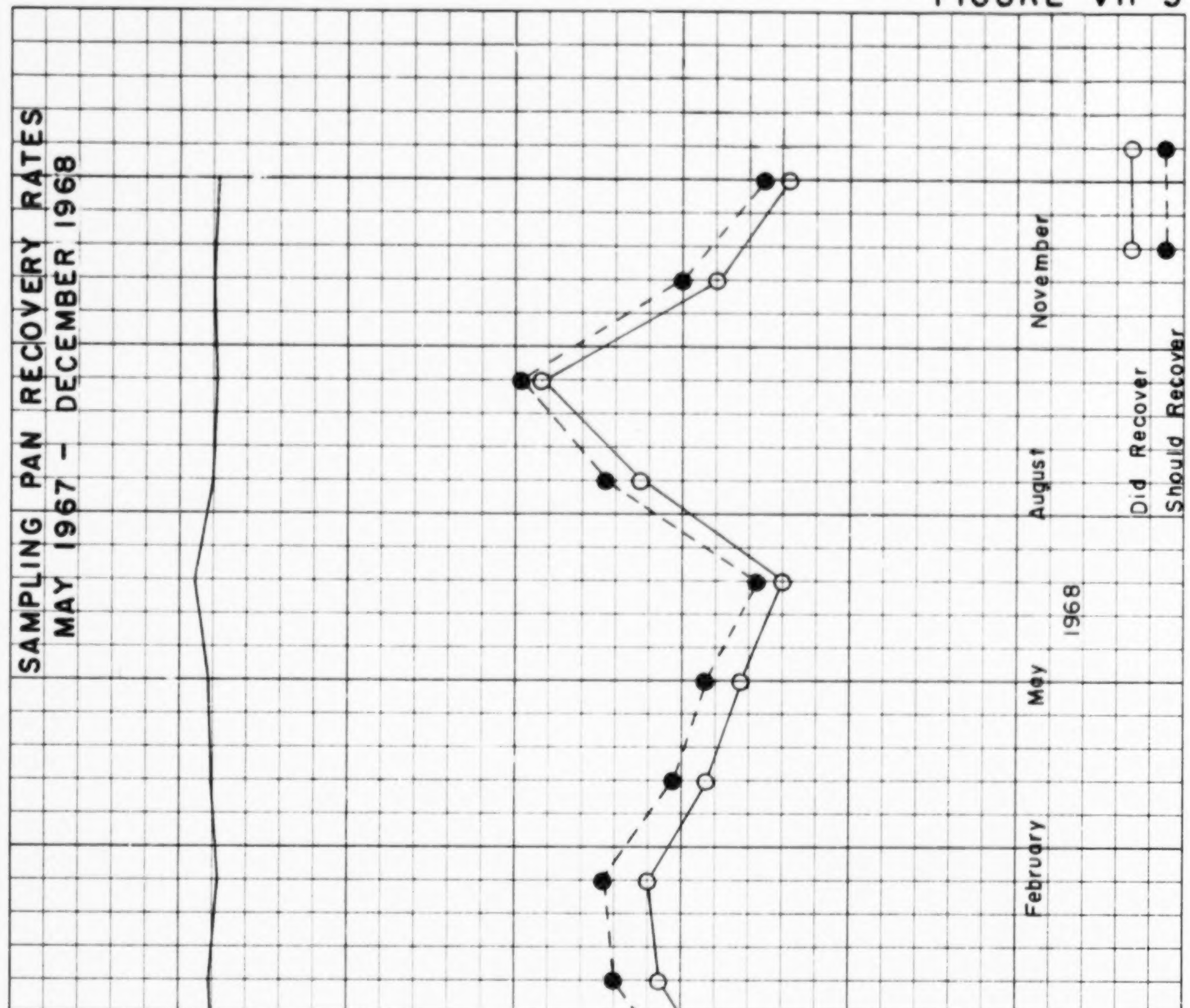

WALKWAY
LEVEE ON FOUR SIDES OF BASIN
10 FT
CENTRAL WELL
SAMPLING PAN
8 FT
1 FT NATURAL
6 FT
2 FT FILL
22 1/2° TYPICAL
8 FT.
4 FT FILL
9 FT
2 FT NATURAL
6 FT
4 FT NATURAL
15 FT
5 FT
8 FT FILL
6 FT
8 FT
1 FT FILL
6 FT FILL
8 FT
6 FT NATURAL
8 FT NATURAL

FIGURE VII-3



SAMPLING PAN RECOVERY RATES
MAY 1967 - DECEMBER 1968

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CHAPTER VIII

GROUND WATER INVESTIGATIONS

Shallow Ground Water

In January 1966 during construction of pipelines for four new spreading basins, water was standing in the bottom of 9-foot deep trenches. This water had not been present a year earlier when the pipelines for the first spreading basins were installed. Investigations to determine the extent, quality and volume of this water began in February 1966.

The first step in this operation included drilling five 48-inch diameter pits into this water using offset, unmortared concrete block around the walls to keep the pits open. Figure VIII-1 shows the location of these five pits and boring logs are shown on Figures VIII-2 through VIII-6. Pipes, to act as piezometers, of 3/4-inch diameter were jetted approximately three feet below standing water near (within 10 feet) four of these pits. The elevation of the water as read from the piezometer tubes and open pits was recorded twice, with one week between readings. These elevations were as follows:

	Pit No.	Pit Elev.	Piezometer Elev.	Difference (ft.)
5/19/66	A	1542.0	1541.6	- 0.4
	B	1537.6	1534.7	- 2.9
	D	1533.4	1535.0	+ 1.6
	E	1528.1	1527.9	- 0.2
5/26/66	A	1541.9	1541.0	- 0.9
	B	1536.7	1536.6	- 0.1
	D	1533.1	1533.4	+ 0.3
	E	1528.4	1528.4	0.0

The signs in the "Difference" column indicate that the water in the piezometer is higher (+) or lower (-) than water in the open pit.

The large discrepancies in water surface elevation between the piezometers and pits was thought to be due to the piezometers not reflecting a slow change of water surface in the soil. Prior to recording another set of readings, the piezometers were pumped, thereby creating a large hydraulic head difference between water in the soil and the empty piezometer. The piezometers recovered rapidly and readings taken after 24 hours showed no appreciable difference between water surfaces in a pit or nearby piezometer. Subsequently, all piezometers are pumped and allowed to recover prior to obtaining a reading of the water mound elevation.

Professor Arthur Pillsbury was retained for his assistance with installation of a network of piezometers to establish the extent, volume and quality of this shallow ground water. Equipment for jetting 3/8-inch pipe piezometers was rented from Coachella Valley County Water District. Under the direction of Professor Pillsbury, piezometers were placed using bentonite as a drilling mud when necessary. When bentonite was used, clear water was circulated through the in-place piezometer to clear the hole of bentonite. A 3/8-inch coupling was screwed on the top of the piezometers and rivets were placed inside the couplings. This formed an effective seal on top of the pipe and prevented foreign material from entering the piezometer.

The original piezometer network was expanded as the shallow water mound expanded. The complete network is shown on Figure VIII-1. Presently, the piezometers are used to obtain water mound elevations and water samples for chemical and bacterial examinations.

Water samples from the 48-inch pits were analyzed for fecal coliform. The pits were heavily chlorinated and this water was then pumped out until the water flowing into the pit had a zero chlorine residual. Of the four pits tested in this manner, three were negative for fecal coliform and Pit D was positive using 10 ml samples. Closer examination of Pit D revealed a dead rabbit in the bottom. Attempts to obtain samples from the pits for bacterial examinations were thereby abandoned as it proved to be too difficult to properly disinfect the pits.

. Chemical analyses of water from the pits and the first piezometers indicated that the shallow ground water was definitely the same as the water being spread. However, several piezometers and pits had water with very high total dissolved solids (TDS) but in a short period the high TDS water disappeared. When it was apparent that the shallow mound was expanding, additional piezometers were installed over a larger area. Some of these new piezometers had water with a very high TDS. Apparently, the high TDS water was the first water spread which had originally leached any accumulated salts from the soil. This water was moving outward from the spreading basins and any samples from the leading edge of the expanding water mound would have a high TDS. Eventually the mound grew larger than the piezometer network.

All piezometers have been installed using jetting methods developed while placing the original network. Many piezometers have required replacement as they have been flooded or damaged. The area southwest of spreading basins No. 5 through 8 is occasionally used for grazing cows. In view of this, the original piezometers in the area were left four feet high with red and blue flagging. Instead of the flagging keeping the cows away, as planned, the cows used the pipes as scratching posts and eventually all of the piezometers were bent over.

Contours of the mound in 1966 indicated that the mound top was about six feet below the bottom of the spreading basins. Figure VIII-7 is a plot of the change in the mound from 1966 to 1967. Figure VIII-8 shows the changes which occurred from 1967 to 1968. These two figures indicate that during some periods most of the water moves in one direction. However, over the entire three and one-half years of spreading, the mound has expanded rather uniformly over the entire area and it has moved upward within several feet of the spreading basins. The present size of the mound is discussed further under the Ground Water Mound section of this chapter. Water quality of the mound is continually monitored through the piezometers and sampling pans. Appendix 2, Volume II of this report, shows the chemical quality of water obtained from the piezometers together with the average chemical quality of the water being spread. It is apparent that the water being spread is the same as that found in the piezometers.

In 1967, 12 water samples from 8 piezometers were analyzed for coliform and fecal coliform. Prior to obtaining a sample each piezometer was heavily chlorinated and the water withdrawn until a chlorine residual of zero was reached. Seven of the 12 samples were positive for coliform, but all 12 were negative for fecal coliform. The eight piezometers sampled with C-2, C-3, D-3, D-5, E-3, E-4, E-5 and F-3. In 1968, 24 samples from 8 piezometers were also examined for fecal coliform. While there were 7 positives for coliform, all were negative for fecal coliform.

After the sampling pans were installed under Basin No. 1, a routine sampling program was established. Figures VIII-9 through VIII-14 are graphs of the data obtained. Each point on these figures represents an average of approximately 20 analyses.

Figure VIII-9 is a graph of of suspended solids versus pan depth and the percentages of suspended solids that are volatile are also shown. There are two apparent anomolies on the graph; i. e., high suspended solids from the four-foot pan in the fill and high percent volatile solids from the six-foot pans. The material in the sample from four feet is probably sand as it has a low percentage of volatile solids. The reason for a high percent volatile from the six-foot pans is not known.

Figure VIII-10 is a plot of nitrate-nitrogen concentration versus pan depth. It is important to note that the two-foot, four-foot and six-foot pans in the natural soil have higher concentrations than the eight-foot pan. However, pans at the same depths in the fill soil don't exhibit the same tendencies. Water from the eight-foot pan in the fill has a nitrate-nitrogen concentration approximately equal to that found in the two- and four-foot pans.

Water samples from each pan have been analyzed for methylene blue alkyl surfactants (MBAS) concentrations. The results are shown on Figure VIII-11. The concentrations of MBAS found in water from either pans in the fill or natural soil are very similar. The MBAS concentrations found in water from the four-foot, six-foot and eight-foot pans is sufficiently low that it is no longer a significant factor. Indeed, the sum of the interference with the testing procedure would probably account for most of the MBAS found.

The chemical oxygen demand (COD), both total and dissolved, is plotted on Figures VIII-12 and VIII-13 respectively. COD concentrations found in water from pans in the natural soil are generally similar to those found in water from pans in the fill soil. The total COD decreases 17 mg/l in the first one foot of soil, 11 mg/l in the next three feet of soil, and only 3 mg/l in the next four feet. That is equivalent to 35% drop in the first foot, 23% drop in the next three feet and approximately 6% drop in the next four feet. The dissolved COD undergoes a 48% drop in the first foot, 11% in the next three feet and only 5% in the last four feet.

Samples from the pans have been analyzed for both coliform and fecal coliform. Figure VIII-14 is a plot of these data versus pan depth. The figure shows the confirmed coliform concentration for the two- and four-foot pan depth samples to be approximately equal. The fecal coliform curve indicates less coliform removal per foot in the two- to four-foot range than any other soil section. This could indicate that samples from the four-foot pans are not being as well filtered as the other samples.(12)

Deep Ground Water

At the outset of this program, a deep well monitoring system was established. Figure VIII-15 shows the location of the wells being monitored. The black squares represent wells located at the beginning of the study, while the black circles represent wells located in 1968. The additional wells were located, hopefully, to provide a more definite picture of the ground water levels and quality. As much background data as possible were gathered pertinent to the wells being monitored. These data include past chemical and/or bacterial analyses and information relative to the static water levels of the wells. Appendix 1, Volume II of this report, contains all the known available data, except the well logs. All of the wells located at the beginning of the study have been sampled and analyzed for chemical quality. Results of water samples from the wells located in 1968 are just now being tabulated. Figure VIII-16 gives deep ground water contours for 1968. These contours indicate a depression north of Main Street from Montrose east to the San Jacinto River. Unquestionably, this depression is caused by heavy pumping. Under the entire area, the ground water profile is reversed by the heavy pumping and this reversal might account for some water quality changes. Figure VIII-17 shows annual deep ground water profiles for the years 1965 through 1968. This profile runs approximately down New York Avenue and is shown in plan view on Figure VIII-16. These profiles indicate that the ground water table has decreased somewhat uniformly along the entire profile line.

Well 4S-1W 23R1 was cleaned out in December 1965. Prior to that time, the well was plugged and recorded as being dry. Also in late 1965, Well 4S-1W 25D2 was dug 820 feet deep using the cable tool drilling method. Soil samples were obtained from each soil lens as the well was being dug. The majority of the soil is a silty sand with various strata ranging from coarse sand to fine silt. Very little gravel and essentially no clay was encountered. Both Well 4S-1W 23R1 and the new cable tool well, 4S-1W 25D2, have 12-inch casings, but the perforation depths are unknown in 23-R1. The perforations in the cable tool well are as follows: 170 feet below the surface to 300 feet; 10-foot zones at 350 feet, 400 feet and 450 feet; 500 feet to 600 feet; 10-foot zones at 650 feet, 700 feet, 750 feet and 800 feet. The entire casing between 170 feet to 300 feet and 500 feet to 600 feet was perforated as these are the strata which contained the coarsest sand. The 10-foot zones were perforated for sampling.

The original reasons for drilling the Cable Tool Well were:

1. To have a deep ground water sampling well south of the spreading basins;
2. To establish a deep soil log in the spreading area;
3. To use this well in the future for pumping the blended ground water and reclaimed water into a water system for reuse.

Since gravel was not encountered, it was doubtful if the Cable Tool Well would be a good production well. This was later confirmed by a pumping test which yielded on the order of 350 gpm with fine sand. The cable tool method was used for drilling so that different zones within the aquifers could be isolated and sampled with a packer pump. A "packer pump" is a submersible pump with inflatable rubber seals above and below the pump intake. Even though the casing is flush against the soil, the packer pump is not as long as the smallest 10' perforated zones and some short-circuiting of the water in the casing above or below the packer pump out into the soil and back into the packer is possible. The percolated wastewater should be obtained by sampling from the top of the ground water. It is possible that a certain amount of intrusion by water from one aquifer into another will occur through the perforations in the well casing. This would be due to the difference in static heads between the separate aquifers. While the piezometer tubes measure the static head in the upper aquifers, a packer pump longer than the perforations, when sealed but not energized, could yield an effective measurement of the static head in deep aquifers. The EMWD packer pump has not yet been equipped to measure these pressures. The water samples which were taken from Well 23-R1 and the Cable Tool Well in May 1966 and shown in Table VIII-1, were obtained by a California Department of Water Resources crew using their packer pump. A packer pump was built by Eastern Municipal Water District, and this pump incorporates the design of packer pumps by Los Angeles County Flood Control District and Dept. of Water Resources. Both of these agencies offered every assistance and very valuable advice during the design of this new packer pump. A sketch of the packer pump is shown in Figure VIII-18. The Cable Tool Well and No. 23-R1 were sampled through the use of EMWD's packer pump in December 1966, July 1967 and November 1968. Results of the analyses of these samples are shown in Tables VIII-2, VIII-3, and VIII-4.

The results of analyses of water obtained through the packer pumps indicates that either there is little chemical quality change with depth in the first

700 feet or that the well is short circuiting, thereby permitting continuous mixing. The next sampling with the packer pump will follow after a prolonged pumping at each level.

Ground Water Mound Size

As noted in Figures VIII-7 and VIII-8 the water mound slowly developed and expanded in area. While data were being developed during the early stages of study, estimates of the amount of water held in the mound were made. Late in 1968 a more refined estimate of the mound size was made using contours and a profile as shown on Figure VIII-19. The known piezometer mound surface was extrapolated and, assuming a similar surface slope for the entire mound and a specific yield of 10%*, the theoretical mound depth was calculated to be 94 feet. The diameter of the mound at the 94-foot level would be 7700 feet.

Many of the new wells added in 1968 to the well monitoring program have shallow static water levels. The perforations are known in some of the recent wells, as well as the older wells. It is planned to check the mound size by plotting all of the wells and check their perforation schedules against the theoretical mound volume. If a well has been perforated within the theoretical volume, the water quality of this well should be affected, irrespective of the static water level in the well. This should be a very valuable tool in checking the mound size.

*The specific yield of 10 percent is based on a recommendation of 12% as an average figure(13) for the entire basin. However, this basin includes some very excellent draining sands in both the Canyon Sub-Basin and Intake Area. The soil under the Replenishment Area undoubtedly had some undrained water on top of the various silt and/or silty clay lenses which are interlaced throughout the entire area. Thus, the recharging program wouldn't replace 12% of the entire volume of soil under the Replenishment Area.

TABLE VIII-1

RESULTS OF ANALYSES OF GROUND WATER FROM CABLE TOOL WELL AND WELL 4S-1W-23R1 THROUGH USE OF PACKER PUMP

(milligrams per liter)

May, 1966

	Cable Tool Well		4S-1W-23R1	Effluent
	190' deep	350' deep	280' deep	1966 Average
Calcium	49	48	38	64
Magnesium	6	6	4	11
Sodium	30	31	23	125
Potassium	3	3	4	19
Ammonium	-	-	-	-
Carbonate	0	0	0	0
Bicarbonate	206	205	178	268
Sulfate	12	13	7	152
Chloride	20	21	13	107
Nitrate	4	4	5	26
Fluoride	0.5	0.5	0.3	0.7
Total Dissolved Solids	262	262	188	671
Boron	Trace	Trace	Trace	0.8
Surfactants	-	-	-	1.7
Hardness as $CaCO_3$	146	145	114	206
E.C. x 10^6	436	438	327	1053
pH	8.0	8.0	7.9	-

TABLE VIII-2

ANALYSES OF SAMPLES FROM GROUND WATER THROUGH USE OF PACKER PUMP, DECEMBER 1966

(milligrams per liter)

Depth to Sample:	Cable Tool Well												Well No. 4S-1W-23R1			Reclamation Facility Effluent 1966 Average
	200	250	300	350	400	450	500	550	596	650	698	750	200	250	300	
Calcium	46	44	43	44	46	46	46	46	46	44	46	45	34	40	40	64
Magnesium	7	6	6	6	7	7	7	8	8	7	7	6	4	5	6	11
Sodium	33	31	30	29	30	30	30	29	30	29	32	30	27	26	26	125
Potassium	3	2	2	3	3	2	3	2	3	2	3	3	2	2	2	19
Ammonia	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.5	0.5	0.6	-
Carbonate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bicarbonate	201	194	192	192	199	200	202	204	206	200	204	202	171	190	190	268
Sulfate	20	13	13	14	14	14	15	14	14	12	24	13	2	1	4	152
Chloride	19	18	17	16	17	16	16	16	16	16	16	16	12	11	12	107
Nitrate	0.9	0.9	1.3	0.9	1.3	1.3	1.8	1.3	1.7	1.3	1.3	1.3	0.5	0.5	0.5	26
Fluoride	0.3	0.2	0.2	0.2	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.2	0.1	0.2	0.2	0.7
T. D. S.	245	226	229	228	235	236	236	244	241	227	234	226	178	194	201	671
Boron	0.12	0.13	0.17	0.20	0.12	0.11	0.16	0.20	0.10	0.16	tr.	0.18	0.17	0.20	0.19	0.8
Surfactants	0.1	0.1	0.1	0	0.1	0	0	0	0	0	0	0	0.1	0.1	0.1	1.75
Hardness as $CaCO_3$	143	136	134	134	142	142	144	146	145	138	142	138	102	122	124	206
ECX 10^6	414	385	384	385	396	393	396	399	397	390	397	392	315	340	339	1053
pH	7.7	7.7	7.6	7.7	7.7	7.7	7.8	7.8	7.8	7.9	7.9	8.0	7.8	7.8	7.8	-

TABLE VIII-3

ANALYSES OF SAMPLES FROM GROUND WATER THROUGH USE OF PACKER PUMP, JULY, 1967

(milligrams per liter)

Depth to Sample:	Cable Tool Well (4S-1W-25D)												Well No. 4S-1W-23R1			Reclamation Facility Average 1966
	200	250	300	350	400	450	500	550	590	650	700	750	200	250	300	
Calcium	45	39	40	38	38	39	39	39	38	39	40	40	31	39	40	64
Magnesium	8	6	6	5	5	6	5	6	5	6	6	6	4	5	4	11
Sodium	30	25	26	26	25	26	-	-	-	-	-	-	24	21	23	125
Potassium	3	2	2	3	2	2	-	-	-	-	-	-	3	2	2	19
Ammonia	0.2	0.4	0.3	0.3	0.4	0.3	0.2	0.2	0.0	0.0	0.0	0.1	0.3	0.2	0.2	-
Carbonate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bicarbonate	198	176	181	168	171	176	171	172	167	176	183	189	161	175	176	268
Sulfate	15	11	6	9	13	11	14	13	15	7	6	6	2	1	1	152
Chloride	17	15	14	15	13	14	14	13	13	13	13	13	11	12	13	107
Nitrate	5	0	4	2	2	2	1.3	1.3	0.9	3.2	3.2	3.2	4	4	5	26'
Fluoride	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.7
T. D. S.	223	191	193	181	187	181	218	212	213	211	214	219	134	166	177	671
Boron	0.14	0.13	0.10	0.15	0.14	0.14	0.02	0.00	0.02	0.02	0.02	0.10	0.09	0.10		0.8
Surfactants	0.1	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	1.75
Hardness as $CaCO_3$	143	122	124	116	118	121	121	120	118	120	124	125	96	119	118	206
ECX 10^6	404	345	345	336	339	349	339	341	340	344	348	354	298	322	340	1053
pH	7.3	7.3	7.4	7.4	7.3	7.3	7.5	7.4	7.5	7.5	7.4	7.5	7.4	7.5	7.5	-

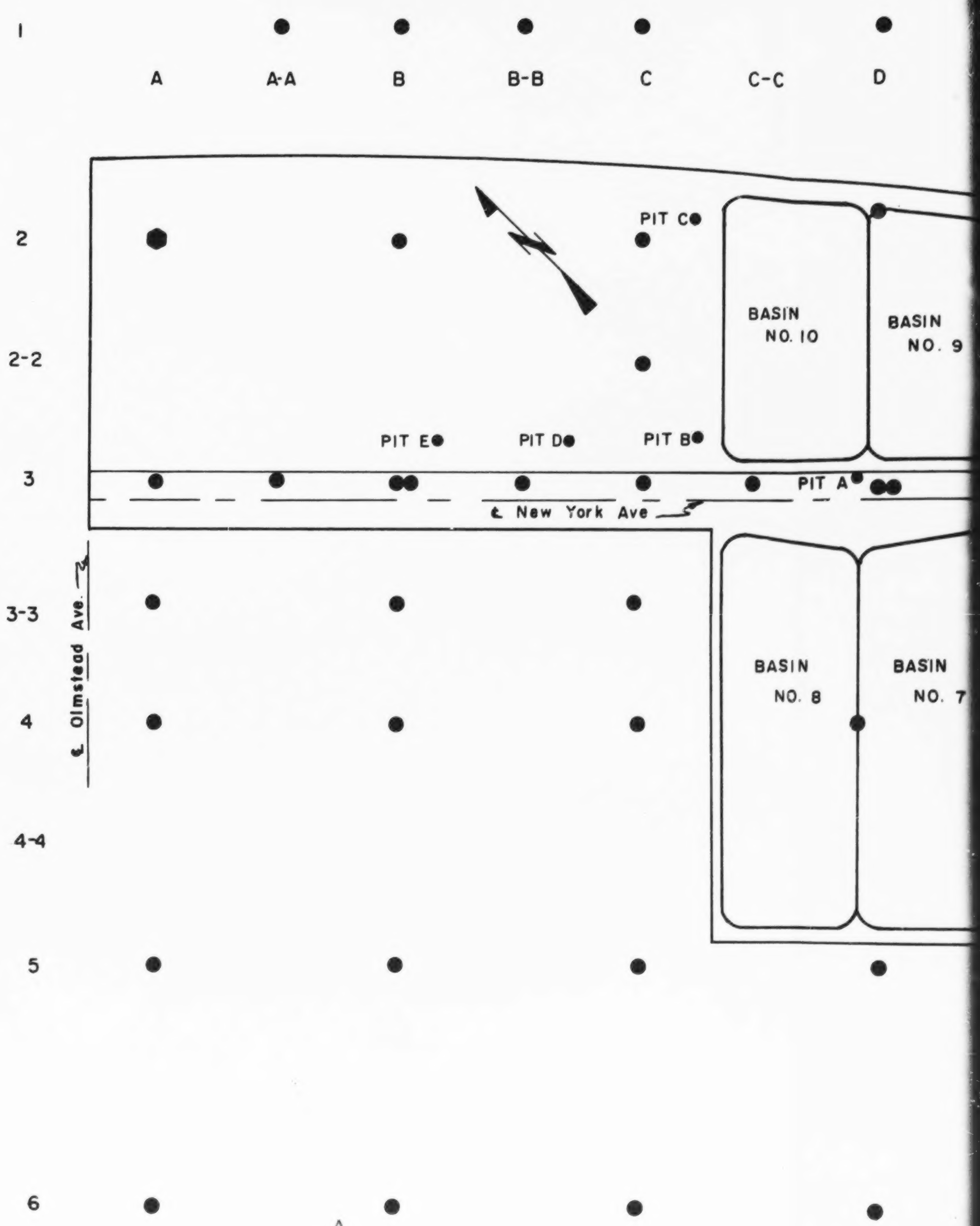
TABLE VIII-4

ANALYSES OF SAMPLES FROM GROUND WATER THROUGH USE OF PACKER PUMP, NOVEMBER 1968

(milligrams per liter)

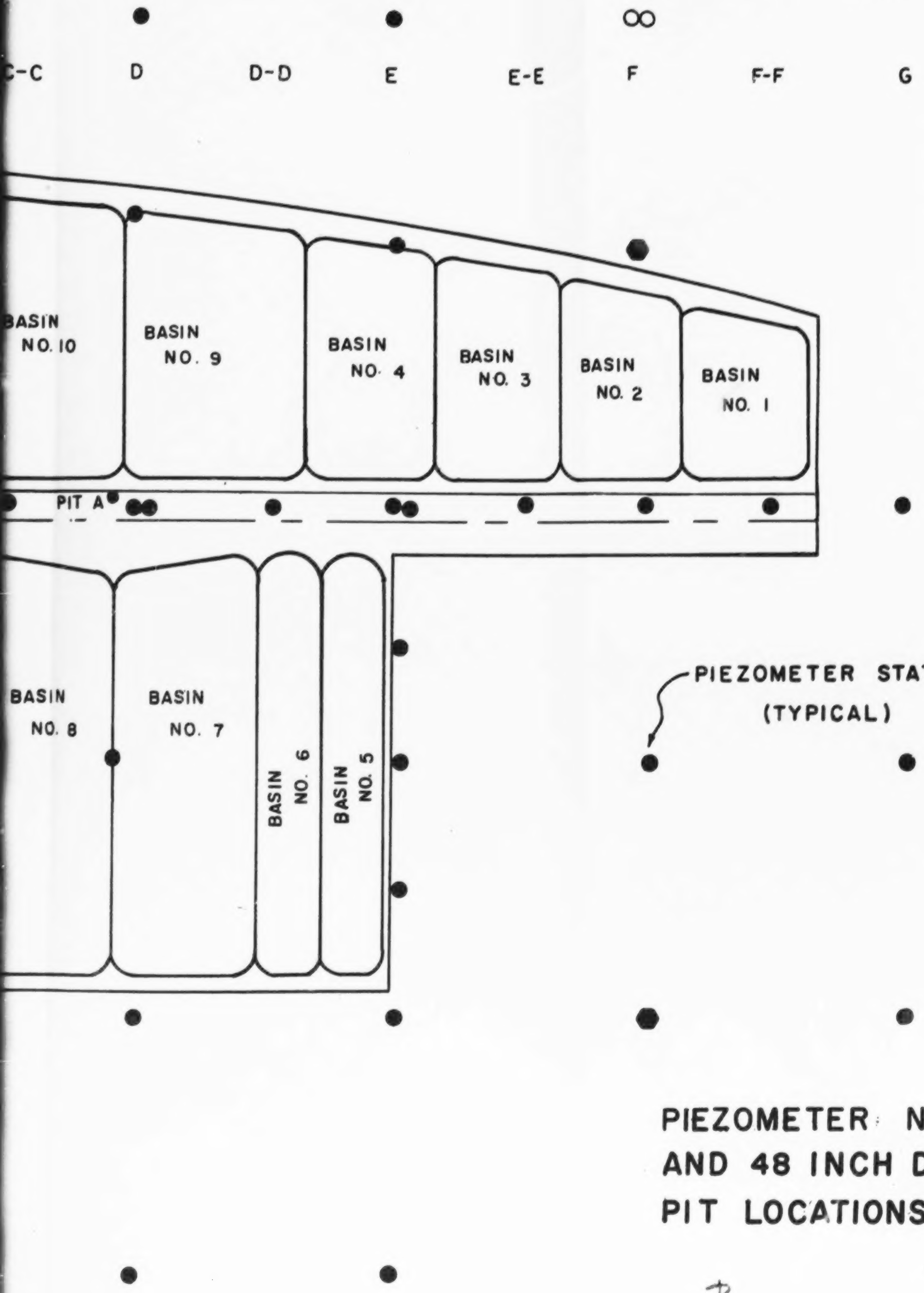
Depth to Sample:	Cable Tool Well (4S-1W-25D)												Well No. 4S-1W-34R1				Reclamation Facility Effluent 1965 - 68
	235*	240	295	350	400	450	505	550	595	650	700	750	200	220	250	300	
Calcium	44	42	42	43	43	42	42	42	42	41	41	41	20	39	40	45	75
Magnesium	2	2	2	2	2	2	2	2	2	2	2	2	3	3	2	2	12
Sodium	23	20	18	19	20	18	18	18	17	15	15	15	23	13	13	12	125
Potassium	3	2	2	2	2	2	2	2	2	2	2	2	5	2	2	2	19
Ammonia	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	0.26	Tr.	Tr.	Tr.	
Carbonate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bicarbonate	136	146	146	150	150	144	144	144	144	140	140	140	110	133	135	133	259
Sulfate	4	5	5	7	7	5	5	5	3	3	3	3	5	1	1	2	131
Chloride	19	17	17	17	17	17	17	17	17	16	16	16	18	18	17	17	114
Nitrate	5	1	2	2	2	4	5	4	3	3	4	4	4	3	2	5	24
Fluoride	.27	.36	.37	.35	.37	.25	.25	.25	.37	.27	.27	.27	.38	.53	.51	.28	0.8
T. D. S.	262	212	210	227	225	242	244	233	227	232	234	233	155	205	201	207	674
Boron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Tr.	Tr.	Tr.	Tr.	0.7
Surfactants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Tr.	Tr.	Tr.	Tr.	1.4
Hardness as $CaCO_3$	118	133	113	116	116	112	112	112	112	110	110	110	63	108	108	122	208
ECX 10^6	405	410	410	410	410	405	405	405	400	400	400	400	400	400	400	400	-
pH	7.95	7.45	7.45	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.65	7.2	7.2	7.55	-

*water surface sample 11/1/68 - non packer pump


1
A
A-A
B
B-B
C
C-C
D
2
2-2
3
3-3
4
4-4
5
6
N
PIT C
PIT E
PIT D
PIT B
PIT A
BASIN NO. 10
BASIN NO. 9
BASIN NO. 8
BASIN NO. 7
℄ New York Ave
℄ Olmstead Ave.

A

FIGURE VIII-1


C-C
D
D-D
E
E-E
F
F-F
G
BASIN NO. 10
BASIN NO. 9
BASIN NO. 4
BASIN NO. 3
BASIN NO. 2
BASIN NO. 1
PIT A
BASIN NO. 8
BASIN NO. 7
BASIN NO. 6
BASIN NO. 5
PIEZOMETER STATION (TYPICAL)

PIEZOMETER NETWORK AND 48 INCH DIAMETER PIT LOCATIONS

B

FIGURE VIII-2

Boring Log
for
Perched Effluent Water

2-28-66
30" bucket
48" reamed and bl

Elevation	Depth (ft.)	Pit A	
	0		Ground Surface
		Silty sand	Fine, greyish-brown damp, moderately firm
1545.0	3.5		
		Sand	Fine to medium, grey, moist
1543.5	5.0		
		Sand	Medium, grey, wet to saturated, caving while boring
1540.17	8.33		
1539.75	8.75	Standing Water	

FIGURE VIII-3

Boring Log
for
Perched Effluent Water

2-28-66
30" bucket
48" reamed and blocked

Elevation	Depth (ft.)	Pit B	
1546.6	0		Ground Surface
		Silty Sand	Fine, greyish-brown, damp, moderately firm
1542.6	4		
		Sand	Fine, light brown, moist, firm
1542.1	4.5		
		Silty sand	Fine, greyish-brown, damp, moderately firm
1541.35	5.25		
		Sand	Fine, light brown, moist, firm
1540.6	6.0		
		Silty Sand	Fine, greyish-brown, damp, moderately firm
1539.94	6.66		
		Sand	Fine, light brown, moist, firm
1538.85	7.75		
		Silty Sand	Fine, greyish-brown, wet moderately firm
1537.1	9.5		
		Sand	Fine to medium, light brown to grey, wet to saturated' loose and caving while drilling
1530.94	15.66		
		Standing Water - water pushing up from bottom	
1530.10	16.5		

FIGURE VIII-4

Boring Log
for
Perched Effluent Water

2-28-66
30" bucket
48" reamed and blocked

Elevation	Depth (ft.)	Pit C	
1546.5	0		Ground Surface
		Silty Sand	Fine, greyish-brown, damp moderately firm
1544.0	2.5		
		Sand	Fine, light brown, moist, firm
1541.5	5.0		
		Silty Sand	Fine, brown, moist, firm
1540.5	6.0		
		Sand	Fine, light brown, moist, firm
1535.5	11.0		
		Silty Sand	Fine, brown, moist, firm
1533.0	13.5		
		Silty Sand with four (4), 2" to 6" sand lenses	
1525.25	21.25		
		Standing Water	
1523.5	23.0		

FIGURE VIII-5

Boring Log
for
Perched Effluent Water

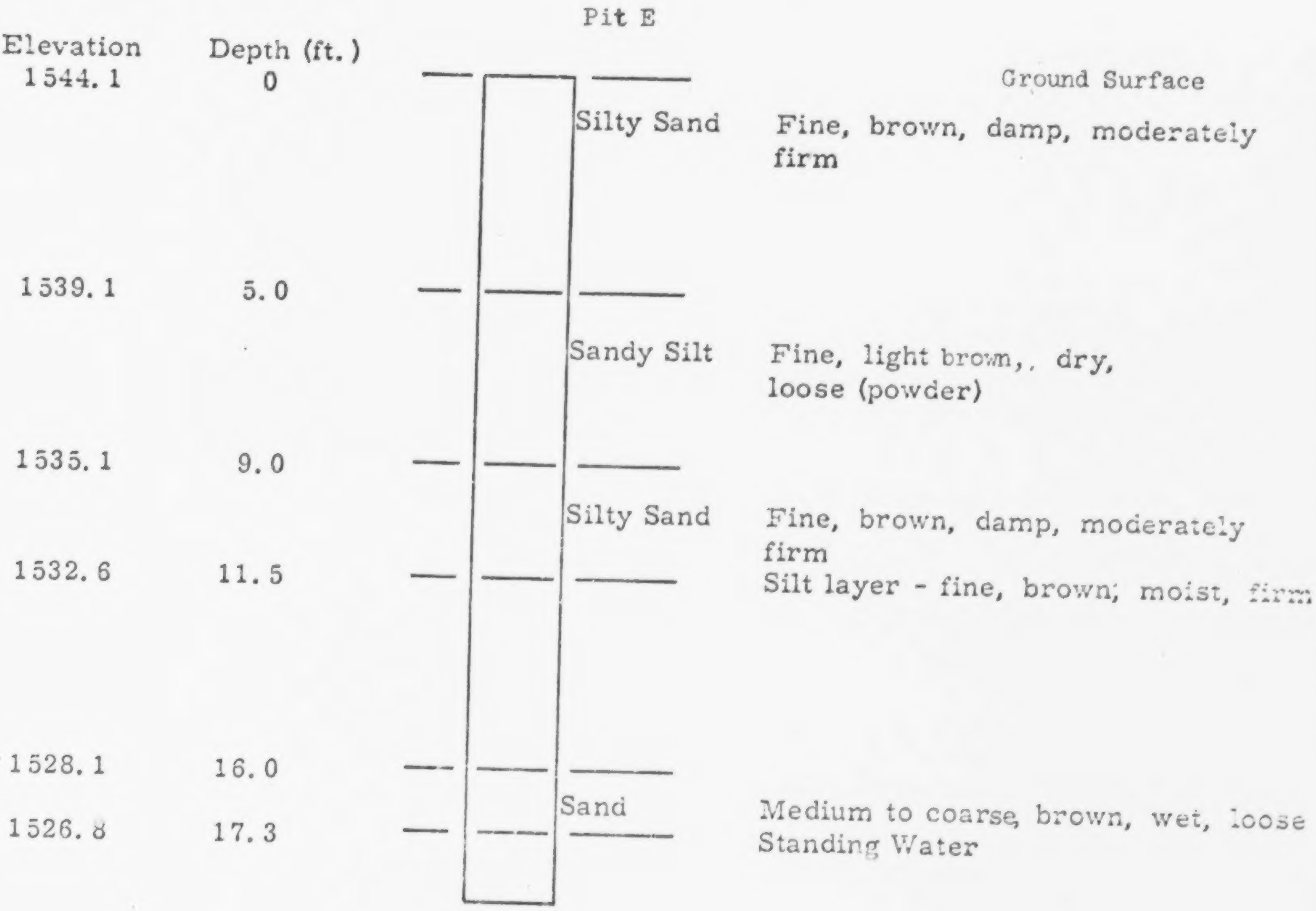
3-1-66
30" hole
48" reamed and blocked

Elevation	Depth (ft.)	Pit D	Ground Surface
1545.4	0	Silty Sand	Fine, brown, damp, moderately firm
1541.4	4.0	Sand	Fine, light brown, moist, firm
1540.4	5.0	Sand	Fine, light brown, dry, loose
1538.9	6.5	Sand	Fine, light brown, moist, firm
1538.57	6.83	Sand	Fine, light brown, dry, loose
1536.4	9.0	Sand	Fine to medium, brown, damp, firm
1534.9	10.5	Sand	Fine, light brown, dry, loose
		Sand	Coarse, brown, damp, firm with one lense of fine, light brown, dry, loose at 12.5
1533.4	12.0		
1529.65	15.75		Standing Water

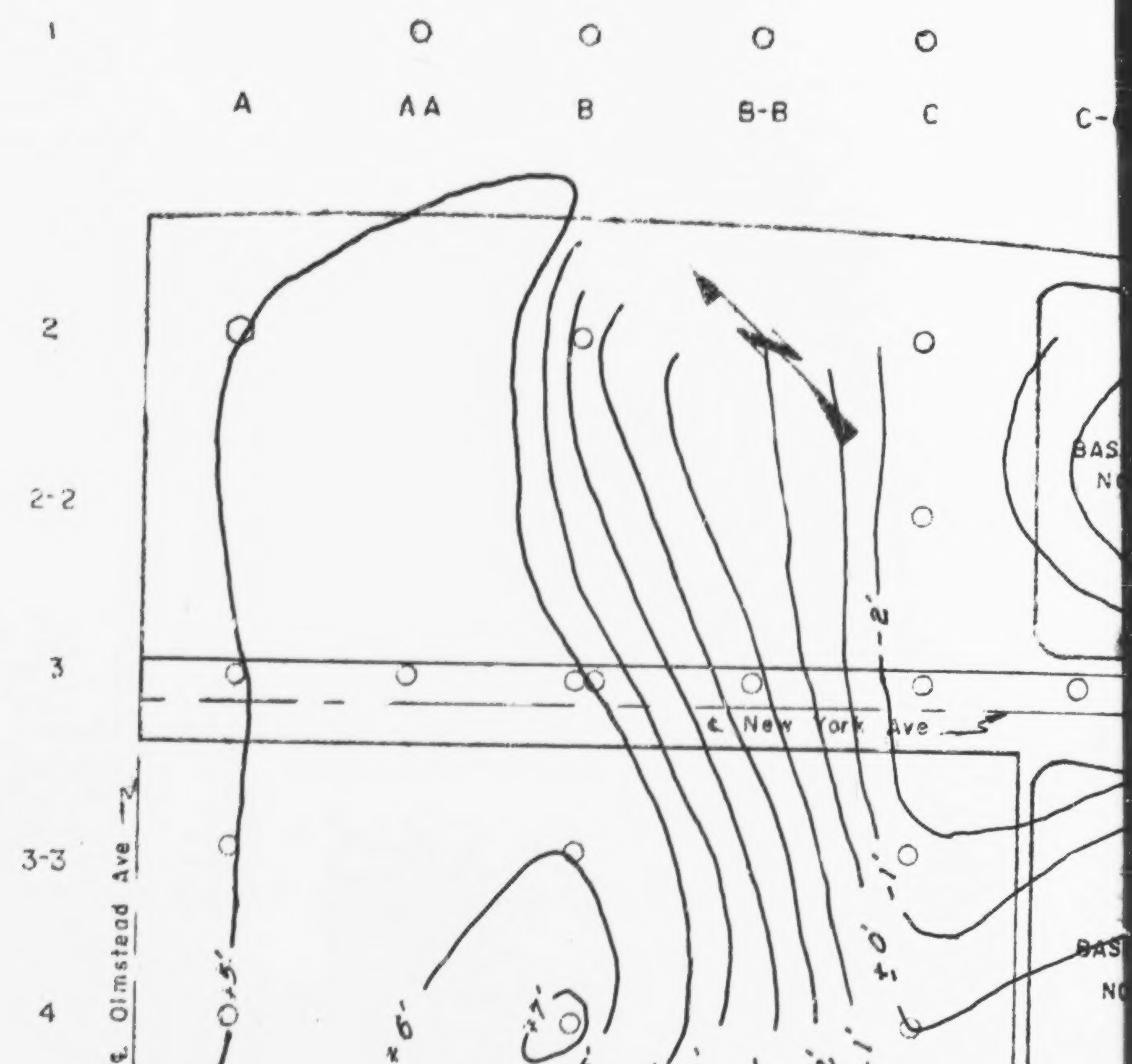
FIGURE VIII-6

Boring Logs for Perched Effluent Water

3-1-66
48" hole, blocked

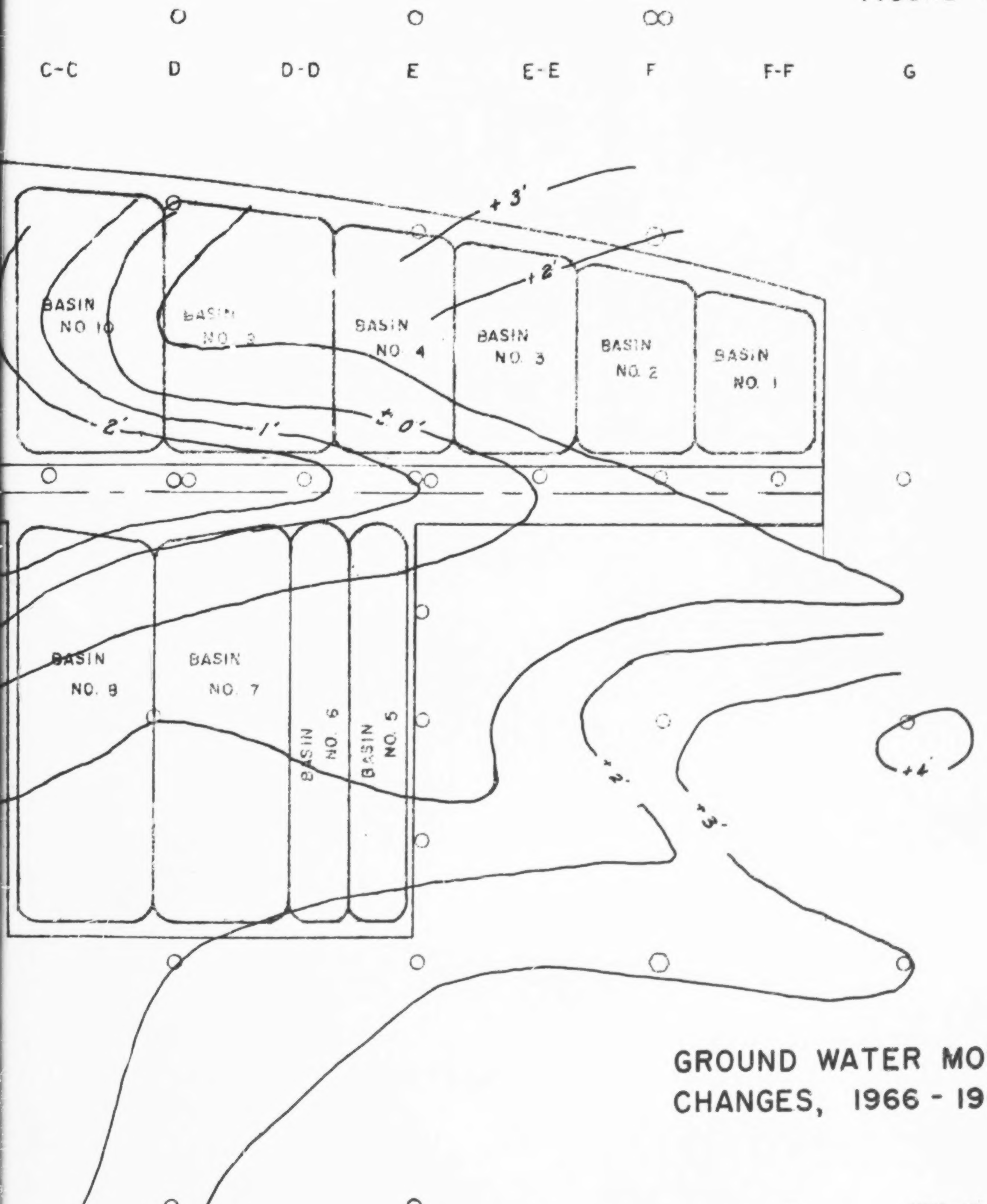


Elevation	Depth (ft.)	Pit E	
1544.1	0		Ground Surface
		Silty Sand	Fine, brown, damp, moderately firm
1539.1	5.0		
		Sandy Silt	Fine, light brown,, dry, loose (powder)
1535.1	9.0		
		Silty Sand	Fine, brown, damp, moderately firm
1532.6	11.5		Silt layer - fine, brown; moist, firm
1528.1	16.0		
		Sand	Medium to coarse, brown, wet, loose
1526.8	17.3		Standing Water


1
A
AA
B
B-B
C
C-
2
2-2
3
3-3
4
4-4
5
6
BAS
NO
BAS
NO
-2'
℄ New York Ave
℄ Olmstead Ave
-1'
±0'
+1'
+2'
+3'
+4'
+5'
+6'
+7'
+6'
+5'

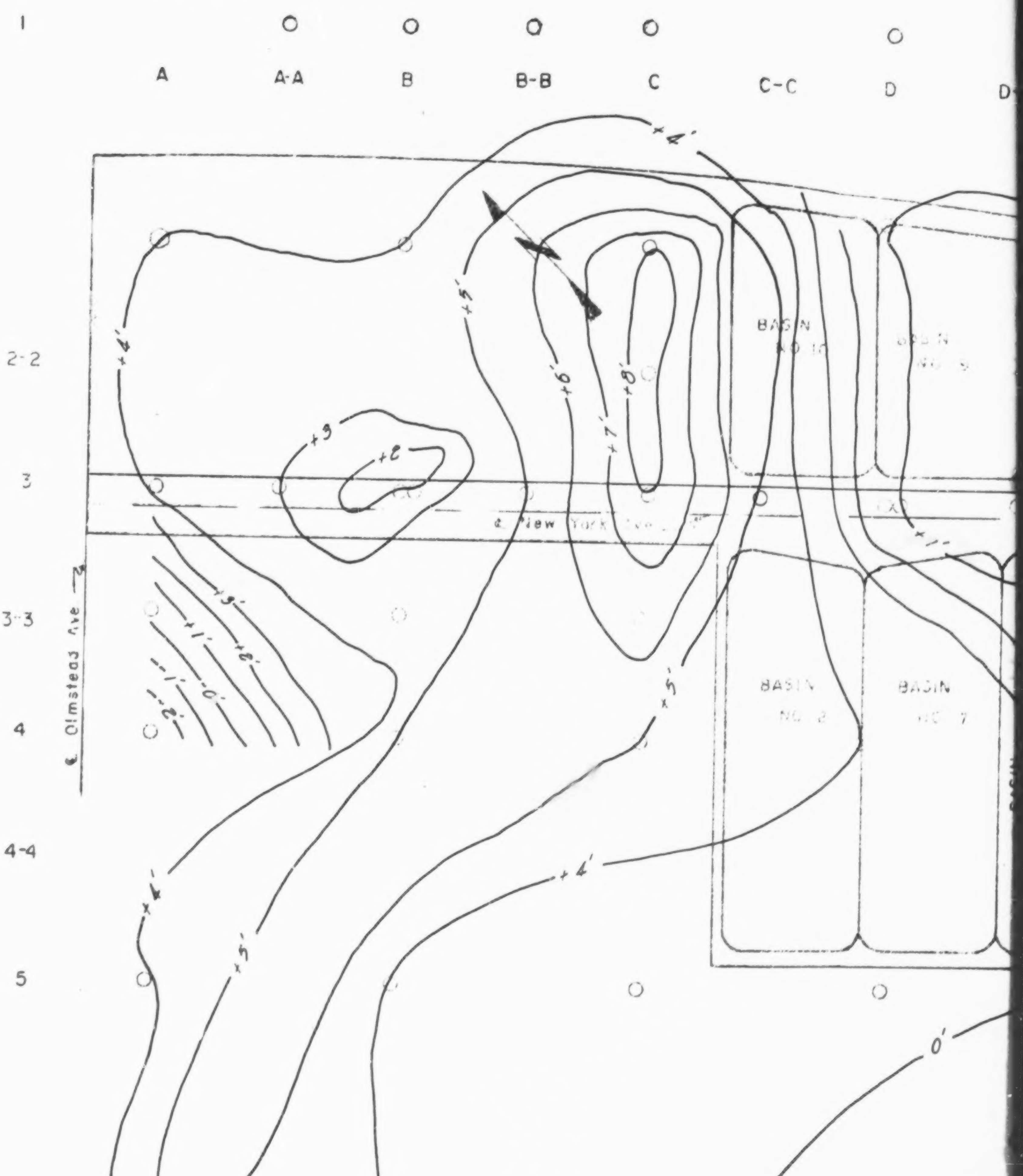
A

FIGURE VIII-7


C-C
D
D-D
E
E-E
F
F-F
G
+3'
+2'
BASIN NO. 10
BASIN NO. 9
BASIN NO. 4
BASIN NO. 3
BASIN NO. 2
BASIN NO. 1
2'
1'
± 0'
BASIN NO. 8
BASIN NO. 7
BASIN NO. 6
BASIN NO. 5
+2'
+3'
+4

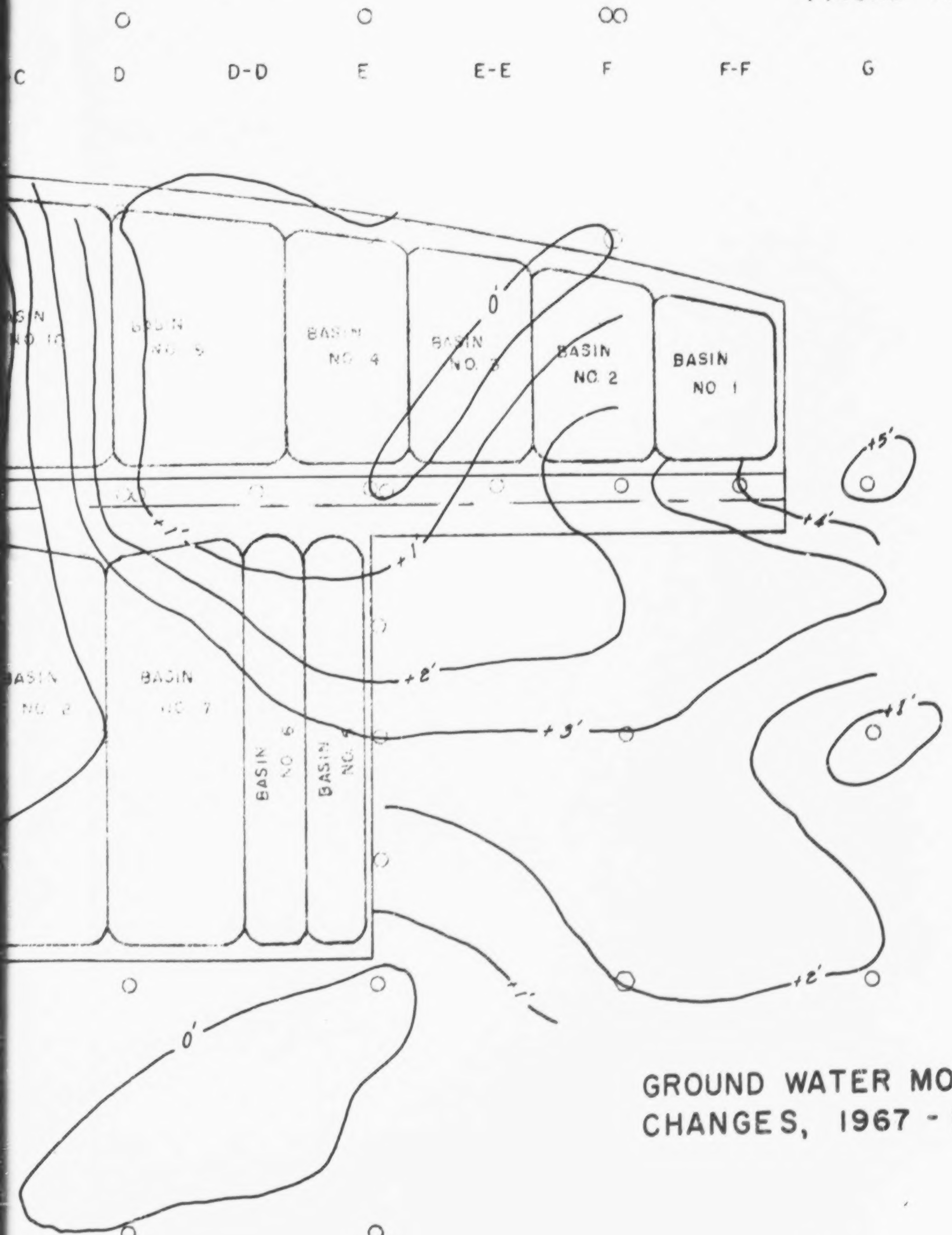
GROUND WATER MOUND CHANGES, 1966 - 1967

B


1
A
A-A
B
B-B
C
C-C
D
D-
2-2
3
3-3
4
4-4
5
6
+4'
+5'
+6'
+7'
+8'
+3
+2
+3'
+2'
+1'
0'
-1'
-2'
+4'
+5'
+4'
+5'
0'
-1'
BASIN NO 1
BASIN NO 6
BASIN NO 2
BASIN NO 7
℄ New York Ave
℄ Olmstead Ave

A

FIGURE VIII-8


C
D
D-D
E
E-E
F
F-F
G
BASIN NO. 10
BASIN NO. 9
BASIN NO. 4
BASIN NO. 3
BASIN NO. 2
BASIN NO. 1
0'
+1'
+1'
+2'
+3'
+4'
+5'
+8'
BASIN NO. 8
BASIN NO. 7
BASIN NO. 6
BASIN NO. 5
+1'
+2'
0'

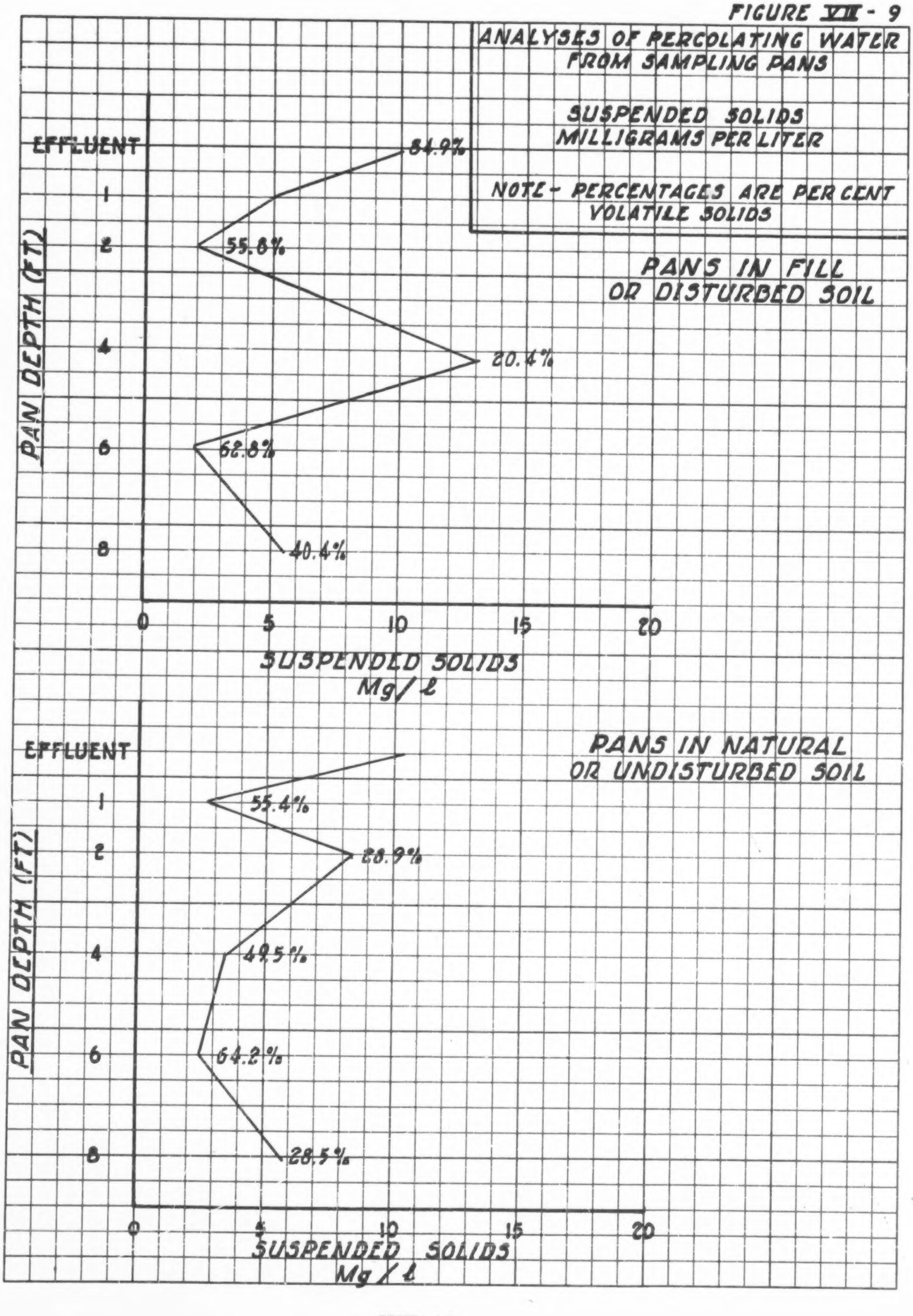
GROUND WATER MOUND CHANGES, 1967 - 1968

B

EUGENE DIETZGEN CO.
MADE IN U.S.A.

NO. 340R-5 DIETZGEN GRAPH PAPER
5 X 5 PER INCH

FIGURE VII - 9



ANALYSES OF PERCOLATING WATER
FROM SAMPLING PANS

SUSPENDED SOLIDS
MILLIGRAMS PER LITER

NOTE - PERCENTAGES ARE PER CENT
VOLATILE SOLIDS

FIGURE VIII-10

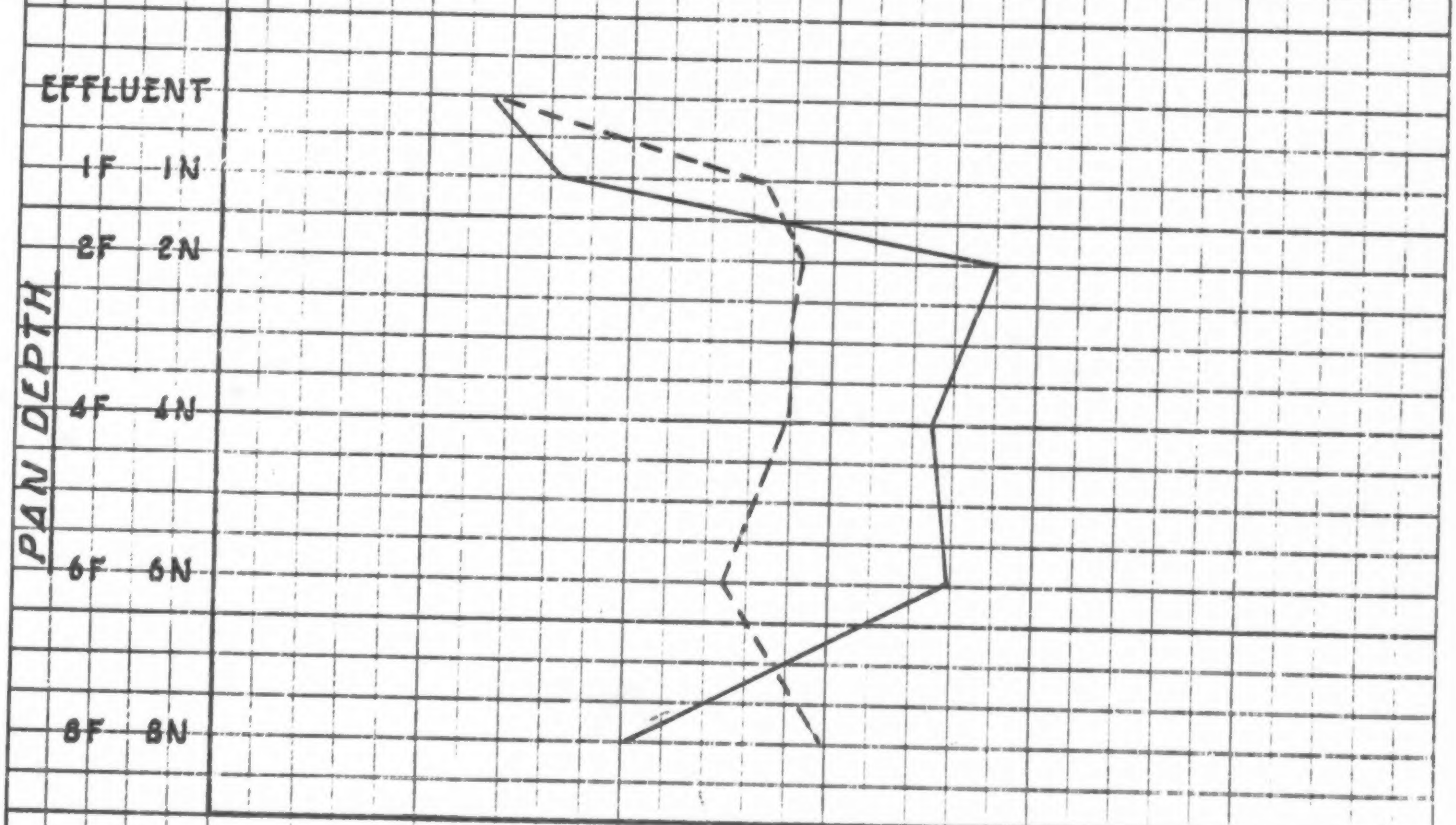
ANALYSES OF PERCOLATING WATER
FROM SAMPLING PANS

NITRATE - NITROGEN
MILLIGRAMS PER LITER

N= PAN IN NATURAL GROUND ——— SOLID LINE

F= PAN IN FILL GROUND - - - - DOTTED LINE

1= NUMBER INDICATES DEPTH OF PAN BELOW GROUND SURFACE



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5 x 5 PER INCH

FIGURE VIII 11

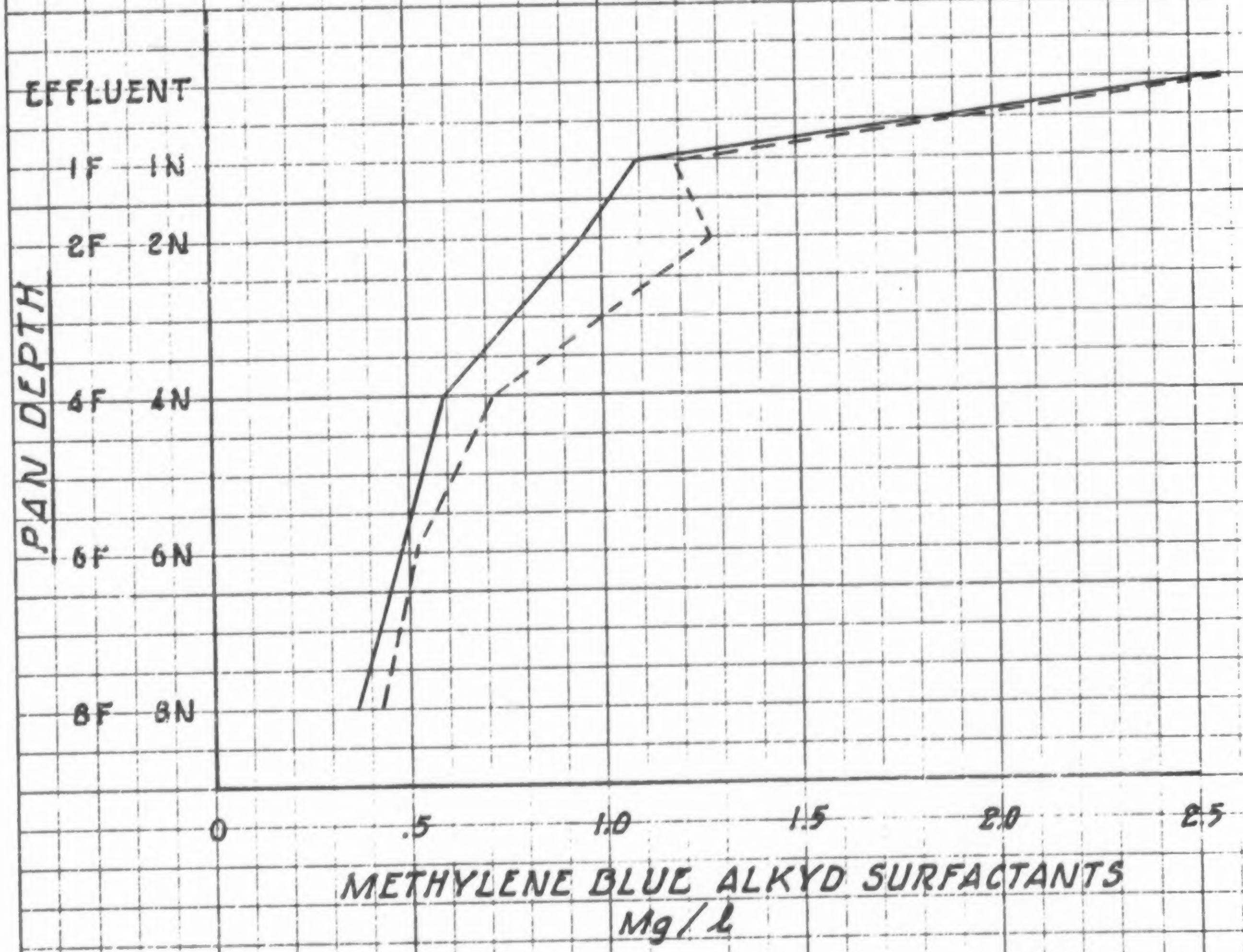
ANALYSES OF PERCOLATING WATER
FROM SAMPLING PANS

METHYLENE BLUE ALKYL SURFACTANTS
MILLIGRAMS PER LITER

N= PAN IN NATURAL GROUND ———
——— SOLID LINE

F = PAN IN FILL GROUND - - - - - -
- - - - - DOTTED LINE

1 = NUMBER INDICATES DEPTH OF
PAN BELOW GROUND SURFACE



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5 x 5 PER INCH

FIGURE VIII-12

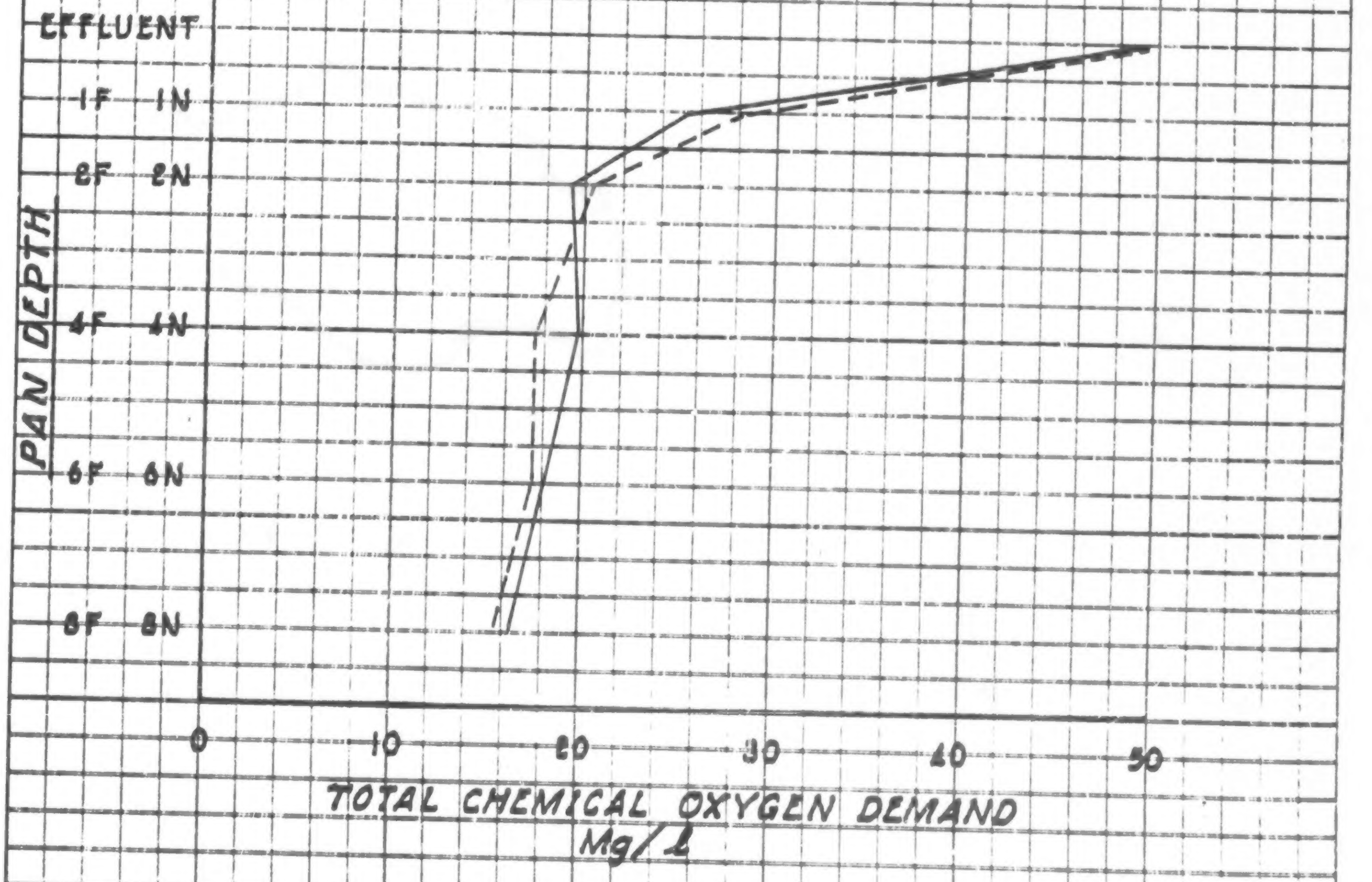
ANALYSES OF PERCOLATING WATER
FROM SAMPLING PANS

CHEMICAL OXYGEN DEMAND (TOTAL)
MILLIGRAMS PER LITER

N= PAN IN NATURAL GROUND ———
——— SOLID LINE

F= PAN IN FILL GROUND – – – – –
– – – – – DOTTED LINE

1 = NUMBER INDICATES DEPTH OF
PAN BELOW GROUND SURFACE



EUGENE DIETZGEN CO.
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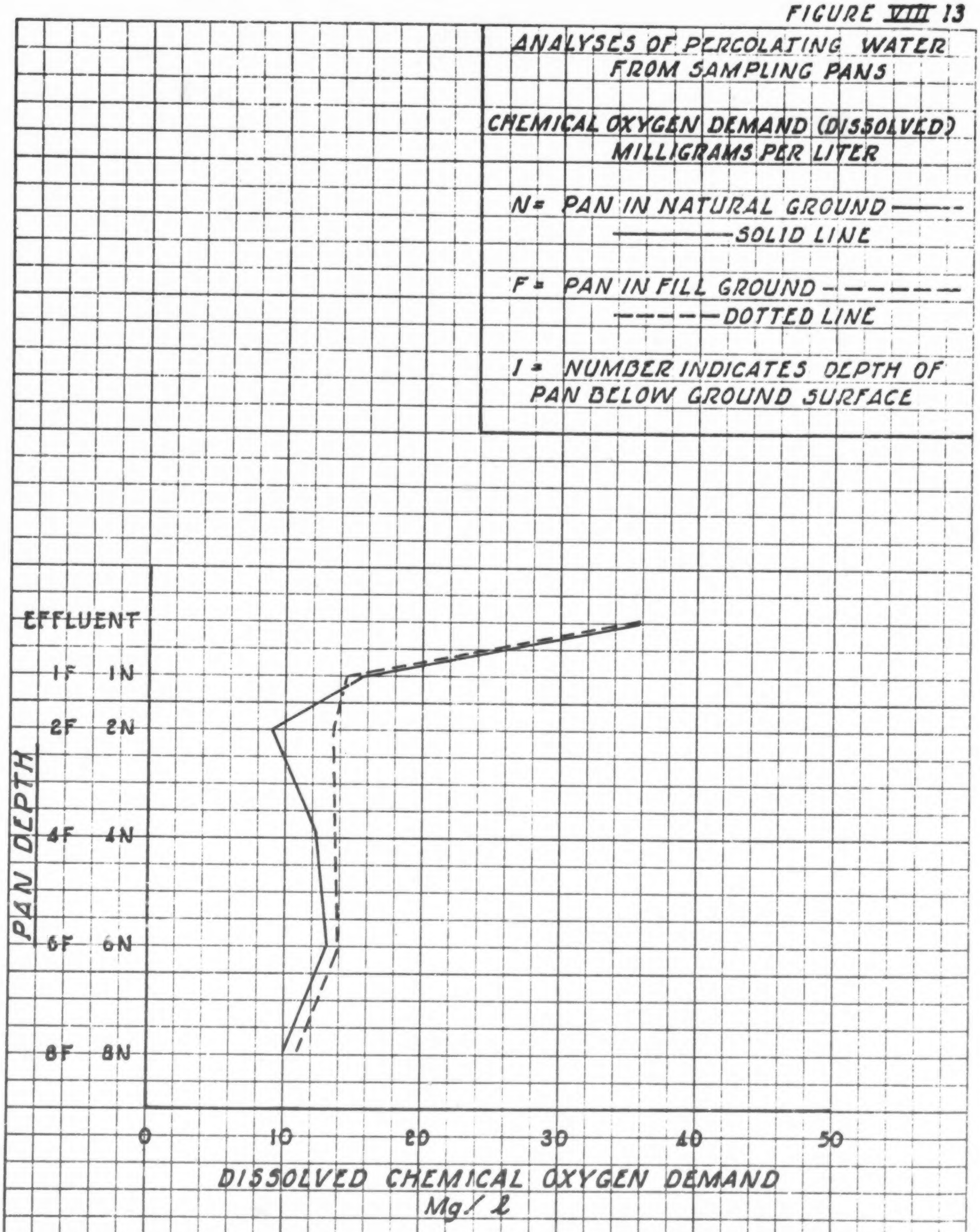
NO. 340R-5 DIETZGEN GRAPH PAPER
5 X 5 PER INCH

FIGURE VIII 13



ANALYSES OF PERCOLATING WATER FROM SAMPLING PANS

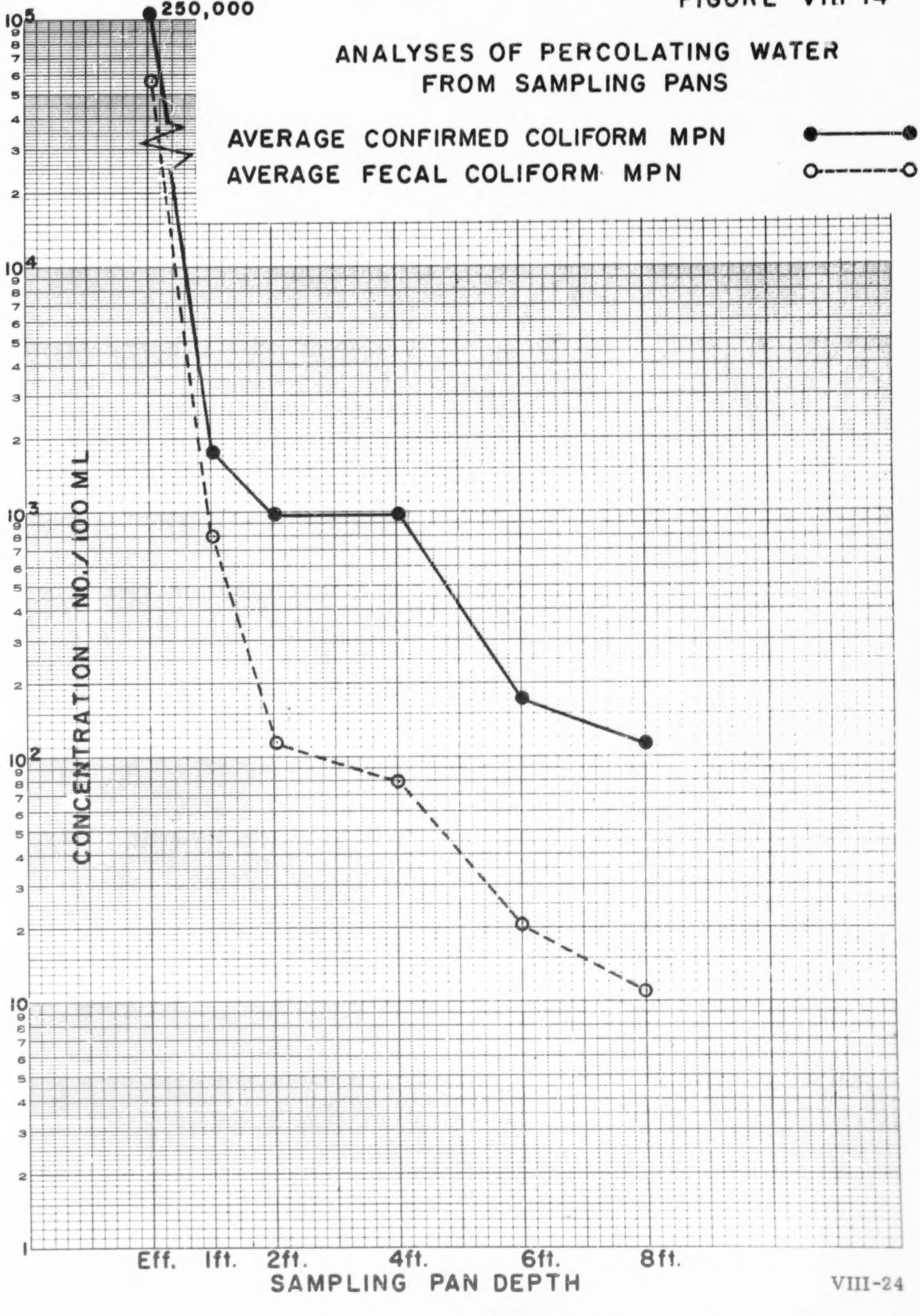
CHEMICAL OXYGEN DEMAND (DISSOLVED) MILLIGRAMS PER LITER

EUGENE DIETZGEN CO.
MADE IN U.S.A.

NO. 340R-5 DIETZGEN GRAPH PAPER
5 X 5 PER INCH

FIGURE VIII-14

ANALYSES OF PERCOLATING WATER FROM SAMPLING PANS



EUGENE DIETZGEN CO.
MADE IN U. S. A.

NO. 340-L510 DIETZGEN GRAPH PAPER
SEMI-LOGARITHMIC
5 CYCLES X 10 DIVISIONS PER INCH

FIGURE VIII-15

WELL LOCATION MAP
TOWNSHIP 4 SOUTH
RANGE 1 WEST
SCALE 1" = 2000'

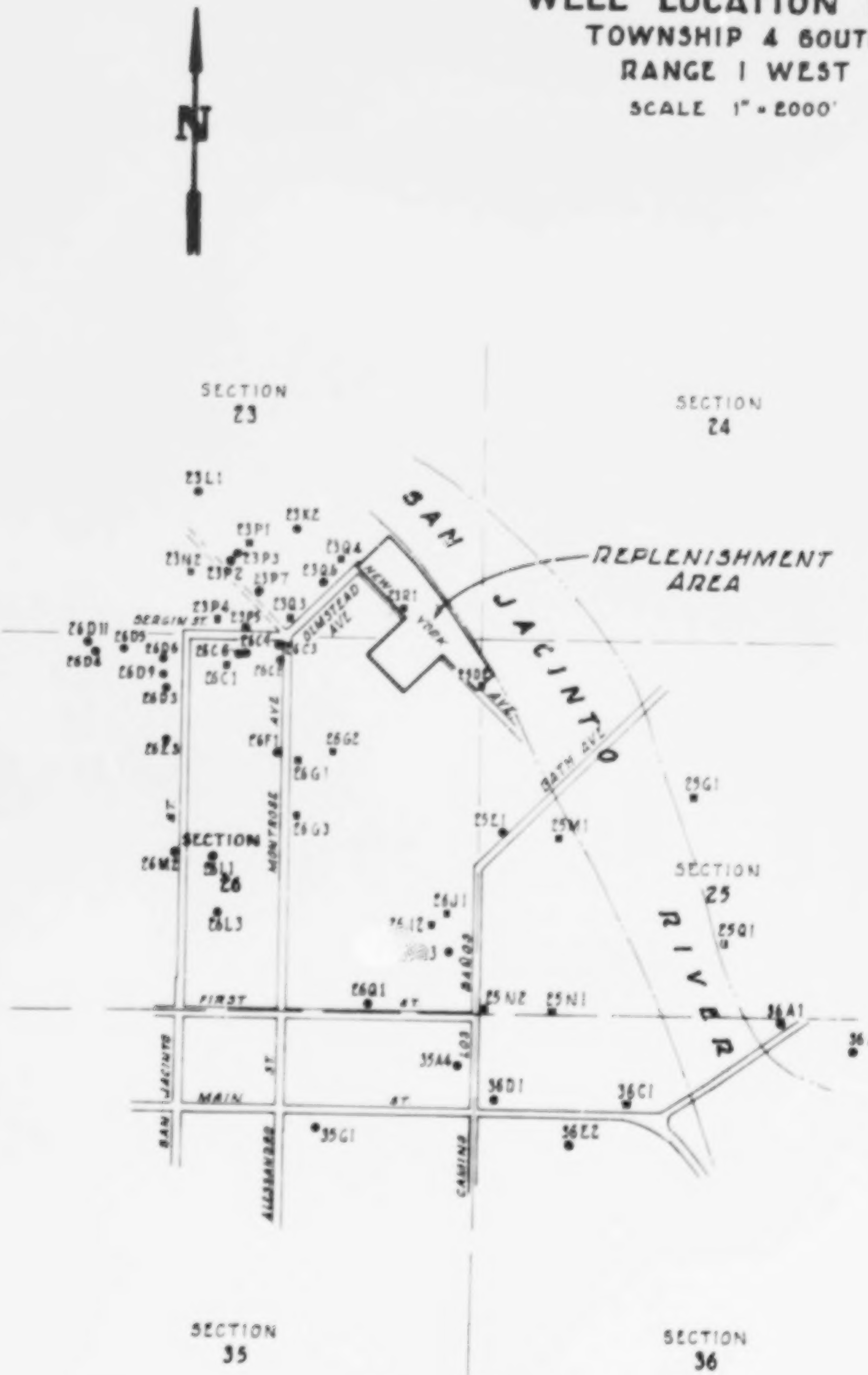

N
SECTION 23
SECTION 24
SECTION 25
SECTION 26
SECTION 35
SECTION 36
SAN JACINTO RIVER
REPLENISHMENT AREA
BERGIN ST.
OLMSTEAD AVE.
NEWPORT
YORK
AVE.
BATH AVE.
MONTROSE AVE.
ST.
FIRST ST.
BARROS
MAIN ST.
SAN JACINTO
ALESSANDRO ST.
CAMINO LOS
23L1
23K2
23P1
23N2
23P3
23P2
23P7
23Q4
23Q6
23R1
23P4
23P5
23Q3
26D11
26D5
26D6
26D4
26D9
26D3
26C6
26C4
26C3
26C1
26C2
26E3
26F1
26G2
26G1
26G3
26M2
26L1
26L3
25D1
25E1
25M1
25G1
26J1
26J2
26J3
25Q1
26Q1
25N2
25N1
36A1
36A2
35A4
36D1
36C1
36E2
35G1

FIGURE VIII - 16

DEEP GROUND WATER CONTOURS

NOVEMBER 1968

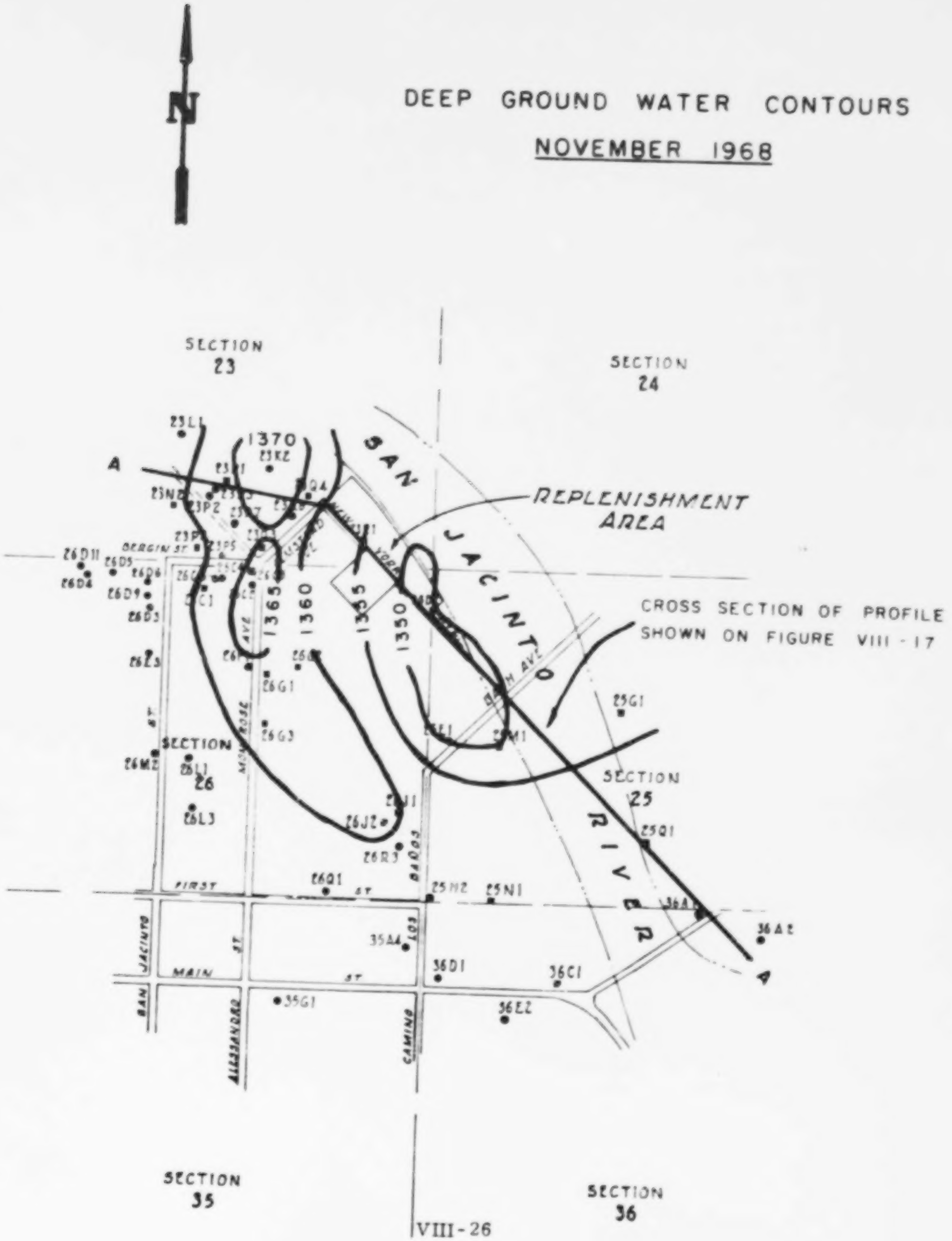
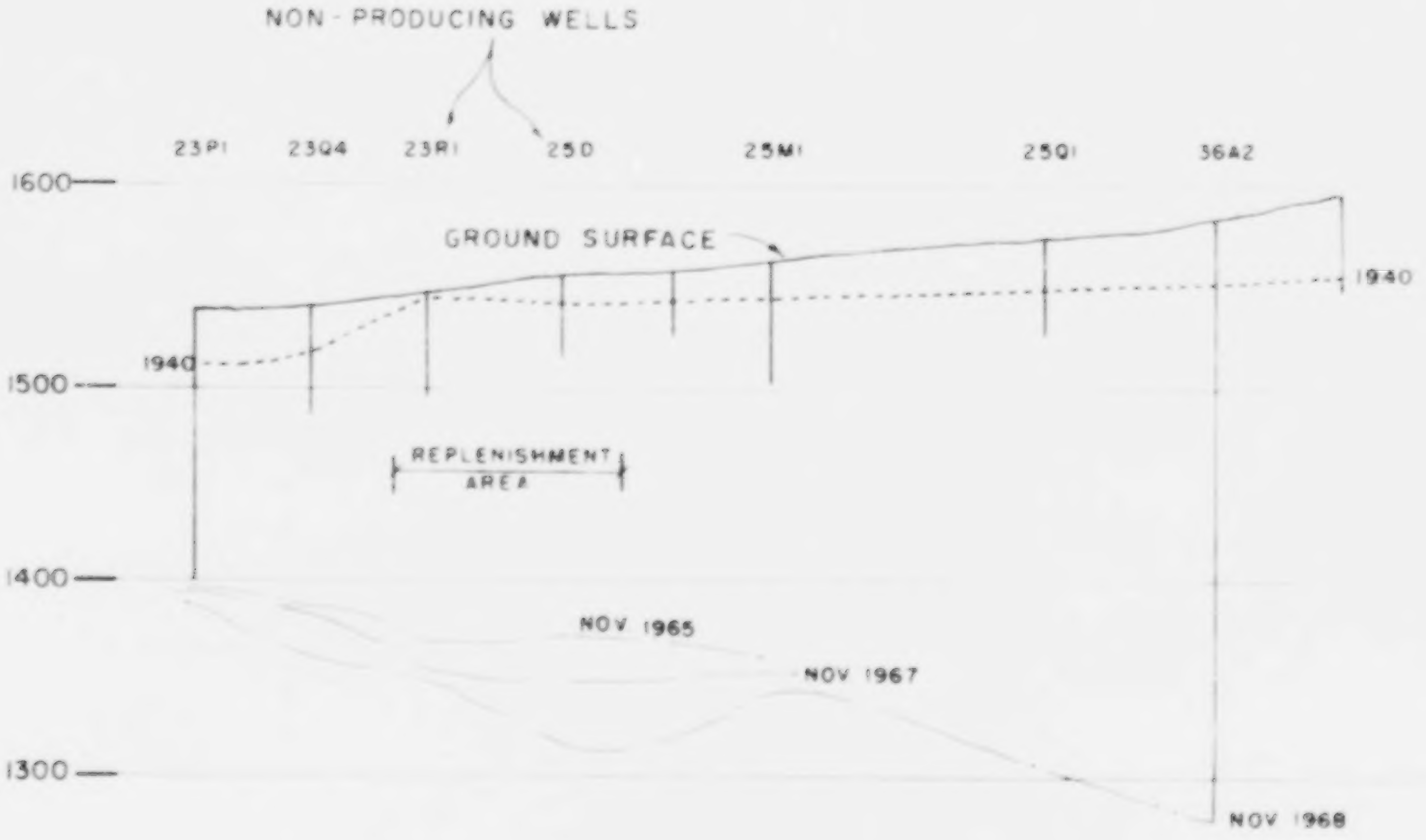

N
SECTION 23
SECTION 24
SECTION 25
SECTION 26
SECTION 35
SECTION 36
A
A
1370
1365
1360
1355
1350
SAN JACINTO RIVER
REPLENISHMENT AREA
CROSS SECTION OF PROFILE SHOWN ON FIGURE VIII - 17
23L1
23K2
23N2
23P2
23P5
26D11
26D5
26D4
26D6
26D9
26D3
26L3
26M2
26L1
26L3
26G1
26G3
26J1
26J2
26R3
26Q1
25G1
25Q1
25N2
25N1
25M1
36A1
36A2
35A4
36D1
36C1
36E2
35G1
BERGIN ST
FIRST ST
MAIN ST
SAN JACINTO
ALESSANDRO ST
MONTROSE AVE
LOS BAÑOS
CAMINO
ELM AVE

FIGURE VIII- 17

PROFILE A-A DEEP GROUND WATER



PROFILE A - A

FIGURE VIII - 18

DIAGRAM OF
PACKER PUMP

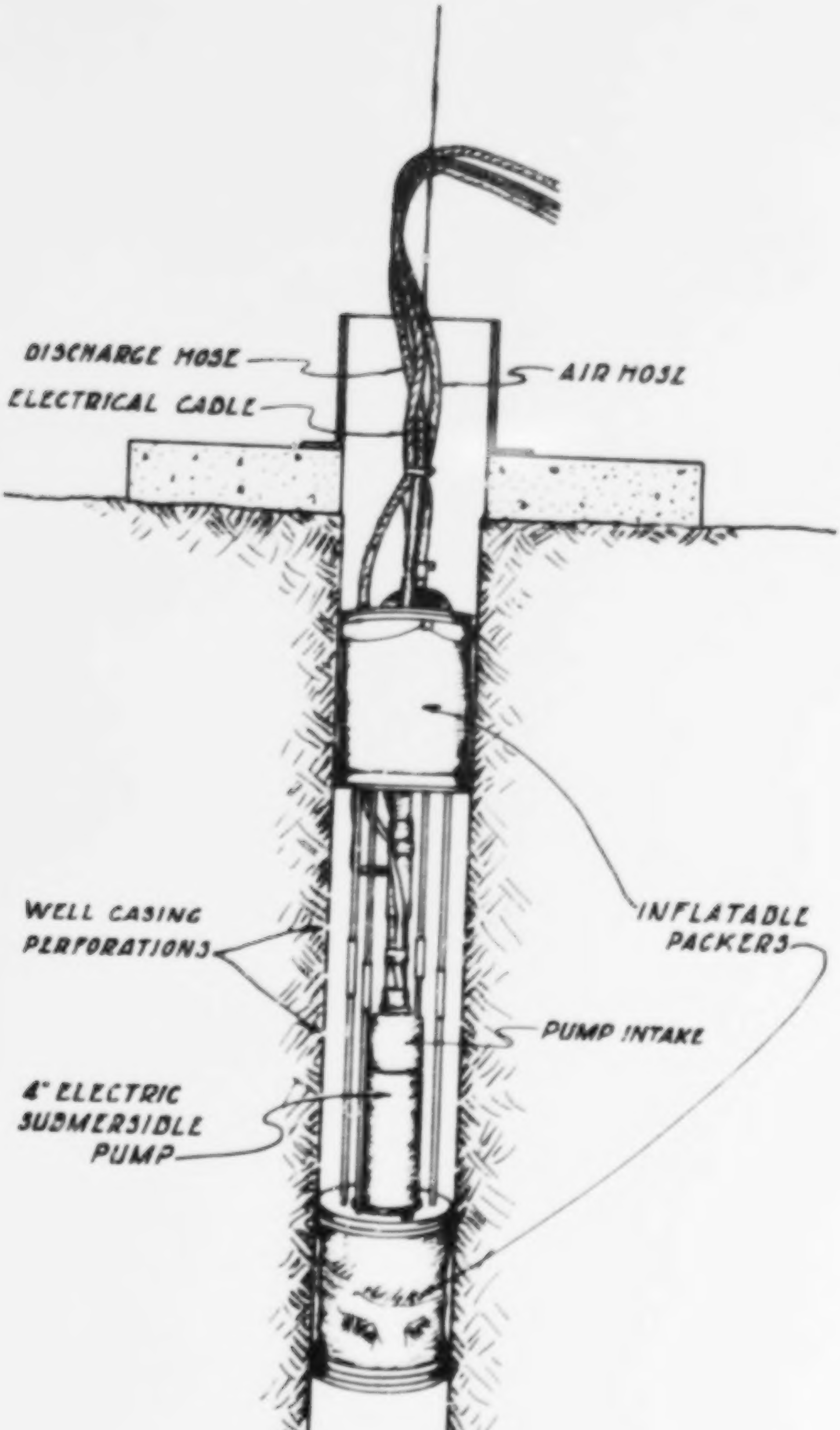
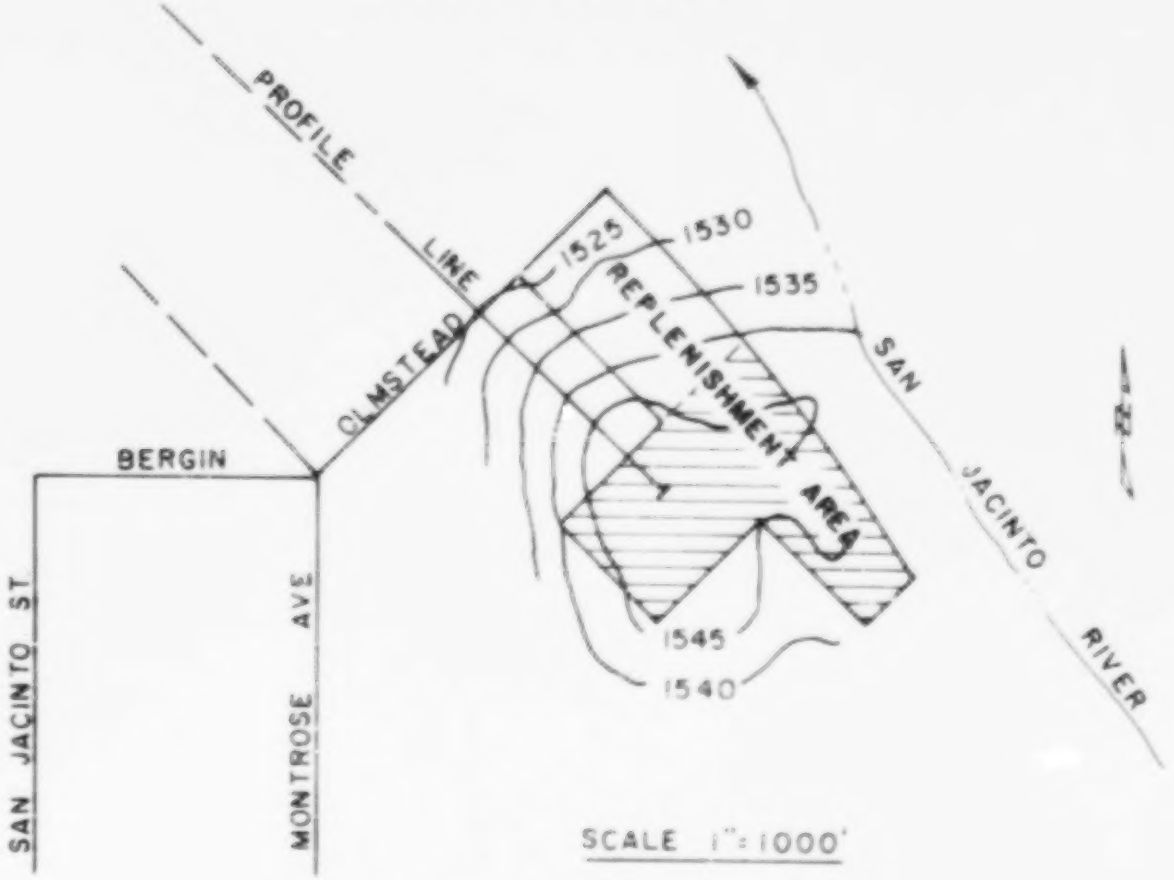

DISCHARGE HOSE
ELECTRICAL CABLE
AIR HOSE
WELL CASING PERFORATIONS
INFLATABLE PACKERS
PUMP INTAKE
4" ELECTRIC SUBMERSIBLE PUMP

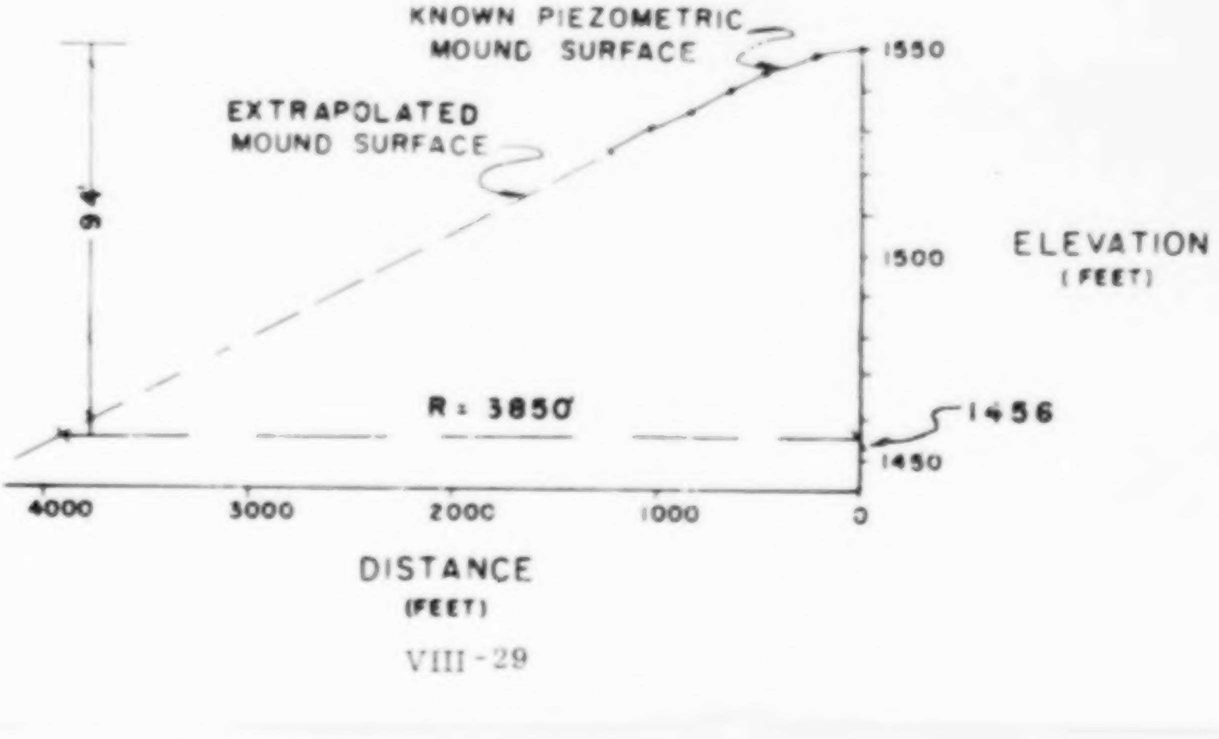
FIGURE VIII-19

PLAN AND PROFILE FOR DEVELOPEMENT OF CALCULATION FOR THEORETICAL MOUND SIZE

NOVEMBER 1968


PROFILE LINE
OLMSTEAD
BERGIN
SAN JACINTO ST
MONTROSE AVE
REPLENISHMENT AREA
SAN JACINTO RIVER
1525
1530
1535
1545
1540
SCALE 1"=1000'

PLAN



CHAPTER IX

WATER ANALYSIS LABORATORY

In the fifties, Eastern Municipal Water District had mainly served Colorado River water for both domestic and agricultural needs. , In the early sixties, the District began construction to implement their earlier planning for a wastewater collection, treatment and disposal system in the Hemet-San Jacinto Valley. Prior to starting water reclamation, the District had only a limited need for bacterial and/or chemical water analyses and the few necessary analyses were being run by local, commercial laboratories.

When this study was conceived, water analyses were to be run by commercial laboratories. However, as the program developed, it was apparent that a greater number of analyses than originally anticipated would be desirable. This need, together with the increasing requirements of the two water reclamation facilities, prompted the District to purchase equipment and to establish a laboratory for complete chemical and bacterial examinations of water and wastewater.

A laboratory has been established at the Hemet-San Jacinto Valley Water Reclamation Facility. This laboratory presently performs all analyses from the District's fresh water system, water reclamation facilities and its research projects. The laboratory has been certified by the State Public Health for complete chemical and bacteriological examinations of water and wastewater. This research program, Reutilization of Wastewater Recycled Through Ground Water, has been saved a substantial amount of money by the establishment of this laboratory.

CHAPTER X

SUMMARY OF FINDINGS

CHAPTER I: INTRODUCTION

CHAPTER II: UPPER SAN JACINTO GROUND WATER BASIN

Description

The Upper San Jacinto River Ground Water Basin lies 30 miles southeast of the City of Riverside in Riverside County and is approximately 54 square miles in area. Ground elevation varies from 2000 feet in the southeast section of the basin to 1420 feet in the northwest section. The San Jacinto Mountains form almost all of the drainage area with Mt. San Jacinto standing 10,805 feet above sea level.

This is a closed ground water basin receiving water from the San Jacinto River which emerges from the mountains into the southeast corner of the basin. Based on well data this basin has been divided into three subbasins.

Hydrogeology:

Canyon Sub-Basin

This area, upstream of the San Jacinto Fault and along the San Jacinto River, has high water levels which fluctuate over 50 feet annually by recharge from the river and heavy pumping withdrawal. These high water levels are partially maintained by the impermeability of the San Jacinto Fault.

Intake Area

This area, downstream from the Canyon Sub-basin, is underlain by highly permeable sedimentary deposits and is recharged from both Bautista Creek and San Jacinto River as well as some ground water flow through the San Jacinto Fault. Also, this area supplies the major portion of water into the pressure area.

Pressure Area

Within the area between the Casa Loma and San Jacinto Faults from the City of San Jacinto northwestward, well logs reveal a substantial thickness of low water bearing sediments. This area was originally artesian but recent years of heavy pumping have depressed ground water level 170 feet. Historically, the northwest boundary of this zone is immediately north of the San Jacinto River where the sediments become relatively impervious.

San Jacinto Fault forms the northern and eastern boundaries of the ground water basin and is somewhat impervious to ground water flow. The Casa Loma Fault traverses the western portion of the basin and inhibits ground water transfer.

CHAPTER III - GEOPHYSICAL INVESTIGATION OF THE UPPER SAN JACINTO GROUND WATER BASIN

Gravity and Seismic Surveys

An attempt to determine the shape and size of this basin from previous information was unsuccessful. It became apparent that wells drilled between the Casa Loma and San Jacinto Faults, north of Park Hill, had not reached bedrock. Dr. Gordon Eaton, Professor of Geophysics at the University of California at Riverside, offered his services and those of a graduate level class to perform gravity and seismic surveys throughout the basin. EMWD did the necessary surveying and furnished supplies. The entire group was enlarged for the actual seismic work when Drs. Shawn Biehler and Stewart Smith of California Institute of Technology joined the effort, together with one of their graduate level classes. John Fett, a local geologist, also worked on this project.

After the original gravity data were obtained it became apparent that the basin depth was so great that it would not influence the water being recharged. However, the basin appeared to be singular throughout the world in width versus depth, so this work was continued.

The gravity survey has aided greatly in determining the bedrock topography southwest of the Casa Loma Fault.

Based on the interpretation of the seismic data and available subsurface information a cross-section of the valley has been constructed. The sediments between the Casa Loma and San Jacinto Faults, a wedge-shaped area, have a depth of over 8,000 feet. This spectacular graben is continuing to increase in depth, as is evidenced by recentness of faulting along both sides of the graben.

CHAPTER IV: SAFE YIELD OF THE UPPER SAN JACINTO GROUND WATER BASIN

Over a period of years the ground water basin has been overpumped resulting in a large drop in ground water levels. Since this overdraft has occurred it has become necessary to know the amount of overdraft and the amount that can be safely pumped annually without an overdraft. This last value is called the safe yield.

In many ways the safe yield report, mainly prepared by Dr. H. G. Schwartz, formerly of California Institute of Technology, updates an earlier report by Majors Fritz and Rosell of the same Institute. Dr. Schwartz corrected several errors in the earlier report and presumably the data presently available for this computation increased the accuracy of the earlier study.

For this report the safe yield is defined as the long-term average volume of water that is naturally recharged to a basin. A 38-year base period was selected, beginning with the 1922-23 fiscal year and ending in 1959-60. The mean precipitation for this period closely approximates the long-term mean for the entire period of record.

The surface inflow to the basin is mainly from the San Jacinto River, and Bautista, Indian, Potrero and Poppet Creeks while most of the surface outflow is assumed to be along the San Jacinto River. The net ground water flow is estimated to be zero.

The annual average change in ground water storage was calculated to be a minus 11,982 acre feet and the annual average safe yield was shown to be equal to 11,205 acre feet.

CHAPTER V: WATER QUALITY

Lack of continuity of data for the same well over a long period of time in or near the Replenishment Area makes it impossible at this time to determine any trends in the chemical content of the ground water. However, based on the 1915 data of Waring, it appears as if the chemical content has been fairly constant.

Present Water Quality

Quality of water being spread is sufficiently different from the existing ground water that mixing and blending of waters will be discernible. The basic water quality tracers used are chloride, sulfate and electrical conductivity. To date only the chloride data have been plotted, but these are sufficient to indicate some changes.

CHAPTER VI: SPREADING BASIN INVESTIGATIONS

Method of Spreading

At the beginning of the project it was decided that the method of applying water in the spreading basins should be one of alternately wetting and drying. It is known that a constantly wet soil will eventually seal. Also, alternately wetting and drying a basin, intermittent spreading, permits air to enter the soil, thus allowing oxygen to reach the soil organisms. These organisms, particularly aerobic bacteria, utilize the free oxygen in biochemical oxidation process and thereby give a form of tertiary treatment to all water spread on the soil.

In the early months of the project several basins were unavoidably continuously wet and clogged tightly, preventing further infiltration of water.

During winter months, a three-day drying cycle is necessary to permit sufficient drying to prevent algae growth.

During the first months of operation the effluent from the Hemet-San Jacinto Valley Water Reclamation Facility had a heavy load of suspended solids. These solids clogged many basins and it was necessary to scarify the basin soil. Following this period, an excessive detection time at the Reclamation Facility permitted a tremendous load of algae to inundate each basin, eventually clogging the soil. These problems were eliminated and during the past 12 months none of the basins have sealed.

Infiltration Rates

The basins have exhibited a decrease in infiltration rates since the beginning of the spreading operation. However, most of the decreases were experienced during the first 18 months, while in the last twelve months the infiltration rates have slightly increased. The infiltration rates and hydraulic load rates demonstrate a yearly cycle with the high in summer and the low in winter. Most of this variation can be attributed to temperature and viscosity changes of the water.

Hydraulic Load Rates

The hydraulic load rates have been low during most of the project, rarely going higher than 0.5 feet/day.

Maintenance

Plant growth in the basins is phenomenal. The growth was cleaned out annually, during the summer, and the cost of the maintenance was very high. The first summer a butane gas was used to burn the dried growth. This repressed regrowth for several months. The second summer the growth was disced under, but regrowth appeared immediately. The third year the growth was mowed with a rotary mower and the top 2 inches of the soil tilled with a large roto-tiller. The last method was the least expensive and the most effective to date. However, it must be noted that discing was done after some of the growth had reseeded.

CHAPTER VII: SAMPLING PANS

To obtain data most efficiently to fulfill several of the project objectives, an underground sampling structure was installed. Investigation of previous work with these underground structures showed that the funnels used to collect the samples were an obstacle to unsaturated flow, thereby creating a long detention time. This detention time, expressed as a lag between the time a particle of water enters the soil and the time this same particle discharges from the sampling system, could be in the magnitude of days. However, it was known that the water actually entered the soil and passed the funnel level in a matter of minutes or hours.

Model Study

Model studies were conducted to eliminate or minimize the inherent detention time of a system capable of sampling water for chemical and bacterial analysis from soil which has water moving at unsaturated flow conditions. These studies were directed toward the funnel or actual sampling device which first meets the water. Six-inch diameter funnels were filled with many different types, grades and graded soils and placed in soil within 55-gallon drums to simulate actual field conditions. These results formed a basis from which the studies were conducted.

Glass wool was placed in the funnels and this arrangement recorded the highest rate of water recovery. The percentage rate of recovery was defined as that volume which is the height of water applied to the soil multiplied by the cross-sectional area of the funnel. These recovery rates were over 90% for the glass wool and less than 10% for different arrangements of soil in the funnels.

Design and Construction

The field installation of the sampling structure consisted of the funnels placed at one, two, four, six and eight-foot depths, in both disturbed (fill) and undisturbed (natural) soils, connected to a central well by use of a plastic pipe. The original installation settled around the funnels in the fill, thereby necessitating reconstruction of this fill. The sampling structure is now in use and the funnels are recovering approximately 90% of the theoretical volume of water.

CHAPTER VIII: GROUND WATER INVESTIGATIONS

Shallow Ground Water

The recharge water, rather than percolating to the deep ground water, has moved horizontally to form a shallow mound. This mound has been delineated through the use of piezometers which are on a grid of 400 feet over the entire area. The top of the mound is only several feet down and it shifts laterally if one basin is recharging considerably more water than another.

Quality of water in the mound is constantly being monitored. Much of the quality data is obtained from analyses of water from both the sampling pans and piezometers. The analyses included Methylene Blue Alkyl Surfactants (MBAS), Ammonium-Nitrogen, Nitrate-Nitrogen (NO_3-N), Total and Dissolved Chemical Oxygen Demand, Suspended and Volatile Solids, Hardness, Total Dissolved Solids, Confirmed and Fecal Coliform. MBAS concentrations drop to less than 0.2 mg/l at the eight-foot level. This low concentration can partially consist of positive interferences in the analysis. Nitrate-Nitrogen concentrations increase down to the four-foot level, then decrease thereafter. Both dissolved and total chemical oxygen demands decrease rapidly as the water percolates downward. The confirmed and fecal coliform concentrations also decrease rapidly as the water percolates through the soil. At the eight-foot level, there is approximately only 1 fecal coliform per milliliter of water.

Deep Ground Water

As much background data as possible have been obtained on the wells surrounding the recharge area. All of these wells have been sampled twice yearly in order that additional background data may be obtained and as a check on the movement of the recharge water. In late 1966, additional wells were found in the nearby area and these wells have been incorporated in the study.

The location of these wells is such that the recharge area is encircled in all directions the water can move. The contours of the deep ground water show a pumping depression to the southeast or upstream.

Several of the wells have had coliform concentrations since the project began, but each time the coliforms have disappeared after chlorinating and have not returned.

A well was dug in the southeast corner of the Replenishment Area, using the cable tool drilling method. This well, used for soil sampling while being dug, will be used as a production well for recycling. It has been tested, and its capacity is only 350 gpm. To date, water samples from this well haven't shown any traces of the recharge water.

A packer pump has been developed to sample both the cable tool well (25D2) and an abandoned well (25H1) immediately north of spreading basin No. 19. This pump design was based on information from Los Angeles County Flood Control District and California Department of Water Resources. It has been run through each well and water has been obtained from specific levels.

Ground Water Mound Size

The size of the mound has been theoretically determined to be 7700 feet in diameter and to be 94 feet deep. The additional wells found in late 1966 will be used to verify this estimate by obtaining and analyzing water samples from the wells which would be within the mound limits.

CHAPTER IX: WATER ANALYSIS LABORATORY

In view of the great number of water analyses to be performed for this project, it was determined to be more economical if EMWD and the FWPCA would purchase equipment to make these analyses, rather than have every sample shipped 30 miles to Riverside for analysis by a commercial laboratory. Equipment was obtained for the laboratory in late 1965 and chemical analyses of water began in early 1966. In late 1966 bacteriological equipment was obtained and these analyses are now being performed.

The laboratory as set up under this project has been certified by California State Public Health Department to be qualified for complete chemical and bacteriological examinations of water and wastewater.

CONCLUSIONS

As noted in the Introduction (Chapter I), the EMWD in 1965 initiated a program for augmenting the water supply resources of the region through planned reclamation by using treated waste effluents from the Hemet-San Jacinto Valley for recharging the Upper San Jacinto Ground Water Basin. Because this basin was believed to be a closed system with limited safe yield, a three-and-one-half year program of research study has been simultaneously carried out, to evaluate the water quality factors associated with the recharging operations in order to develop information to enable the EMWD to carry out its reclamation and reuse program in a manner which prevents deterioration of ground water quality. This program has been extended for three additional years. The conclusions from the first three-and-one-half years of study may be summarized as follows:

A. Reclamation as Related to Regional Water Supply

(1) The geology and hydrology investigations confirmed that the ground water basin does have a limited safe yield, of approximately 11,205 acre-feet/year, and the basin is essentially a closed system with little outflow.

(2) The volumes of water reclaimed and put underground to replenish the overdraft have averaged approximately 1430 acre-feet/year over the past three-and-one-half years, or about 13 percent of the safe yield, and because of anticipated population growth it is expected this will increase by the year 1980 to about 17,000 acre-feet/year or 151 percent; these percentages represent a large volume of water which will have significant effects on ground water quality.

(3) The volumes of reclaimed water (now averaging 1600 acre-feet/year and expected to reach 17,000 acre-feet/year by 1980) represent a sizable contribution in meeting regional water supply needs. By comparison, ground water withdrawals now approximate 1[illegible]000 acre-feet/year and importation of Colorado River water approximates 1900 acre-feet/year.

(4) The total annual inflow of salt into the basin is now estimated at 5800 ton/year, comprising 3900 ton/year from inflowing ground water and 1900 ton/year from imported Colorado River water. The reclamation operation in effect produces an additional supply of water with only a small addition of salt to the basin. Importation of the same volume of Colorado River water would increase

the total salt loading by about 400 percent under present conditions. Also, by comparison, without planned reclamation (assuming the waste effluents were discharged to the San Jacinto River cone, to infiltrate and/or evaporate under unplanned conditions) it is estimated that approximately 10 percent of the wastewater would be evaporated unnecessarily and therefore lost. Also, this replenishment program has a much smaller impact on salt balance than would an agricultural reuse of the water.

(5) Because of items (1) through (4) above, it is concluded that reclamation by recharging is an important component of the District's overall water supply program and should be continued indefinitely but under sufficient controls to maintain satisfactory ground water quality.

E. Spreading Operations

(1) The studies of the spreading operations confirm the findings of earlier studies elsewhere (e.g., Lodi, California and Whittier Narrows, California) that alternate wetting and drying is necessary to maintain aerobic conditions in the surface soil and to prevent sealing. For the conditions at EMWD, a three-day cycle of wetting and drying appears to be the most feasible.

(2) As experienced elsewhere both infiltration (and hydraulic loading) rates progressively decreased from initial higher values, over the three-year period, to a fairly steady range of from 1 to 2 feet/day (infiltration); however, the trend of the data indicates that the spreading beds are beginning to experience "ripening" and hopefully the rates will gradually increase (as occurred at Whittier Narrows) so that eventually much higher rates can be maintained.

(3) Control of weed growths in the basin has been a problem. Use of a rototiller appears to offer the best method of control.

(4) The infiltration rates noted in (2) above represented spreading beds with no special attention to the surface other than for periodic mowing of weeds. It appears that infiltration rates might be substantially improved by covering the surface with pea gravel. To verify this, Basin No. 3 was covered with six inches of pea gravel in May 1968. Other possibilities for improvement of infiltration rates might be by rototilling to a depth of two or more inches and by permitting weed growth. The feasibility of these methods shorld be investigated.

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27 Abstract
The water quality factors involved in the recharging of the San Jacinto Basin, California are evaluated so that the overall operation may be conducted in a manner to provide adequate protection of groundwater quality while permitting reclamation of wastes for regional water conservation. Another objective is to study the benefits to the salt balance problem caused by recharging. In the previous situation, some effluents were discharged to the San Jacinto River area and some were used as irrigation water. With recharge there is a significant reduction in evapotranspiration losses, thus improving groundwater quality by diluting the dissolved salts. The safe groundwater yield is limited to approximately 11,205 acre-feet/year. The volumes of water reclaimed and put underground to replenish the overdraft now average approximately 1430 acre-feet/year. Withdrawals now approximate 12,000 acre-feet/year. and importation of Colorado River water approximates 1900 acre-feet/year. Inflow of salt into the basin is now estimated at 5800 ton/year; 3900 ton/year from inflowing groundwater and 1900 ton/year from imported Colorado River water. (Knapp USGS)

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